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SCIENCE AND  
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TEACHERS**

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Science, Ethics, and War  
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# SCHOOL SCIENCE AND MATHEMATICS

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## SCIENCE, ETHICS, AND WAR\*

E. R. HEDRICK

*Vice-President and Provost, University of California  
at Los Angeles, Los Angeles, California*

Some two years ago I discussed publicly the relations between science, economics, and possible war, with emphasis upon the distressing economic situation which indeed still faces us. I was then impressed mainly by the misunderstanding, which still exists, by those who attribute to science and to invention our sorry industrial and social plight. To this, since there is a connection, I shall recur briefly today.

Meanwhile, however, an old menace which most of us had hoped was on the wane has not only reappeared, but has grown suddenly to proportions never known in the modern world: morality between nations, and all ethics, have been not only forgotten, but actually openly derided. Men in high places have advocated deceit, force, cruelty, and have laughed at weaklings who maintain truth, justice and mercy.

It seems to me, therefore, that the outstanding world issue of the present is no longer the economic one, grave as that is, but rather the even more fundamental one of the preservation of ethics in human conduct. Today, therefore, I wish to consider with you the relations of science with ethics, and I have added *war* to the list in my title, since war is now actual.

Widespread war *always* brings in its wake serious weakening of moral and ethical codes, but *this time* the world *enters* war with debased standards of ethics. Before war in Europe was de-

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\* Address delivered at the Annual Meeting of the Central Association of Science and Mathematics Teachers, Chicago, November 24, 1939.

clared, men in power preached and practised falsehood, advocated and glorified war, cleared paths to power by the cruelties and cynicism of what they called purges. Not merely the criminal element, as in this country, but the very rulers, grasped and held power by such foul means. That I do not exaggerate is clear from the many published statements of impartial and well-informed persons. Thus Mark Sullivan, in an article entitled "Where Are the Promises Men Live By?" in a recent issue of *Current History* (see also the *Readers Digest* for November, 1939) says

Faithlessness has actually become a cult. Great nations baldly teach their youth that any lie, any false promise is blameless if uttered to advance the interests of the state. Nor is this mere doctrine; it is practiced. One pledge after another has been contemptuously broken—no need even to recite the examples, so recent and so notorious are they. So low has sunk the credit of the pledged word that it has led to spectacles perhaps unparalleled in history. Germany repeatedly and solemnly assures the world that it has no intention of violating the neutrality of Holland or of Belgium. The only effect of these reiterated pledges is to make Holland and Belgium increasingly apprehensive.

This and similar evidence fully justify what I have said.

With such a background *before* war, the threat to civilized ethics seems to me greater than ever before in modern times. It is no longer a question merely of the economic situation, nor even of any ideal of this or that political system. The whole world is in danger of total debauch in which ethics are completely forgotten. And we in this country—even if we succeed in keeping ourselves out of direct participation in war itself—cannot keep from being affected by a world-wide loss of moral and ethical values. While our material welfare is still in danger, I believe that our spiritual welfare is at once more important (even to human happiness) and more endangered.

For this situation also, science is blamed by many. Not a week passes but that well-meaning persons besiege my office—and probably the executive offices of every university—with the honest belief that science is undermining morality and ethics, and that there is a fundamental conflict between science and religion, whose keynote is ethics.

As you know, science and associated invention have been blamed, equally honestly and equally mistakenly, for our economic woes, and more particularly for what is now called "technological unemployment." I have pointed out elsewhere that those who hold such views are ignorant of industrial history: the English "*industrial revolution*" of just about a century ago

illustrated in detail both the temporary economic derangement and the eventual tremendous social and economic gains that are caused by invention. The invention of the steam engine and of the power loom did throw men out of employment and did result in riots and destruction of both life and property, but these inventions soon increased enormously both opportunity for employment and the whole scale of living of the British people. What was at fault was not the *invention*; it was the bad management of men and of industry and the insane belief that the destruction of machinery was the way back to prosperity.

Science is blamed by many also for war and for the horrors that we foresee in the present actual war. In an article on "Science and Ethics" in the October (1939) issue of the *Scientific Monthly*, E. G. Conklin, recently president of the American Association for the Advancement of Science, treats some of these questions, although his main thesis is the *evolution* of ethics, rather than its other implications. I shall quote from him liberally in what I say today. Regarding the charge that science is responsible for war and its horrors, he says:

Many persons are saying in these evil days that science has made possible the horrors of modern war and the question is seriously asked by thousands of people whether the invention of high explosives, poison gases, submarines, and airplanes has not been a curse rather than a blessing. Instruments of aggressive war may always be considered curses, but the scientific discoveries which made these possible are usually blessings.

Indeed, science is in no way responsible for war, for its horrors, for economic breakdown, or for moral or ethical degeneracy. Science seeks only truth and the good of mankind. The evil results are due to evil misuse by those who are not scientists.

Every good thing can be—and often is—abused, misused, perverted. Quite aside from science and invention, if we consider any good thing, we will find abuses and perversions of it. Thus *friendship* is a source of good and of great happiness to man; it, too, is often abused, perverted, turned into evil. *Love* is a major human blessing; yet its abuses and perversions fill the pages of the history of human misery also. *Trust* in others is almost essential to society; yet it too is abused and perverted until it has become in some senses a by-word; we speak of "confidence-men."

So also every invention, every major step in science and discovery has seen misuse, abuse, perversion.

The *wheel* was one of the early inventions of man. Its contribution to civilization and to man's progress are limitless: with-

out it, commerce, industry, and the greatest part of man's conquest over nature, would have been impossible.

*Fire*, and its control by man, constitute another major achievement of early man.

*Metals*, and their refinement from crude ores lifted man out of the stone age.

All these—*wheel, fire, metal*—have contributed to evil, also, and to war. Without them there would have been no swords, no lances, no war chariots, no flaming fagots thrown to destroy men's habitations, no blistering torture of hot iron branding the captive. But such misuse, such abuse, does not lead us to condemn their invention, nor to deplore a knowledge of them. We know that the major reason for them was *good*, and that the major result of them has been advancement of mankind, increase in happiness, increase in the scale of human living. We therefore adjudge them *good*, despite the evil misuse that may be made of them by evil men.

The invention of writing, of printing, of the telegraph and telephone, of radio, have led to evil as well as to the great good which led men to them. Even in wars: the use of these in communication is now an essential element of war. But to assess their merits, we must count the enormous service to man's *good*, and we must count the evil as misuse and as perversion.

And so it is with every major scientific advance, with every major field of invention. The invention of boats and navigation, a prime benefit to man, is also used in war, and has been since the beginnings of written history: yet this knowledge was primarily for good, and has served mankind enormously.

Steam engines, gas engines, electricity, all have a like history. Even the explosives that are most directly war-like are only a small element in the great progress of modern chemistry: the whole range of organic chemistry, of which modern explosives form a small part, have been primarily for man's good and have advanced civilization; I need only mention the coal-tar dyes and other derivatives, with which modern explosives are closely allied, to emphasize this truth. The other associated developments of the plastics (phenol-derivatives and others) and the intricate medical compounds such as salvarsan and sulphonyrydine are outstanding benefits to man.

Our knowledge of radio and of supersonic devices may be used in war. Shall we blame science also for that? Such scientific discoveries are made primarily for man's benefit, in every in-

stance. Science cannot prevent the use of knowledge for evil purposes, either by the burglar who uses an explosive to wreck a safe, by the bandit who uses the automobile to effect his escape, or by the war-makers to spread havoc and misery. It is here that law-makers and statesmen may intervene, by restrictions upon burglars and bandits and war-makers, if indeed there be any international law remaining in a world gone mad. If bacteria are used in future wars, the scientists who work with such things are powerless to prevent it. The blame must not be laid against such scientific leaders as Pasteur, however, for he was an apostle of man's good and man's advancement. The blame, if such misuse of our knowledge of bacteria does occur, must be laid at the door of those who authorize its use, or at the door of those who make no adequate provisions of international laws to prevent it.

Even at the very worst, with every conceivable misuse of scientific knowledge by reckless belligerents, the net result of scientific knowledge will be to lessen the horrors of wars. In wars of the past, even as late as our own Spanish-American war, disease and ignorance killed more men than bullets. The use of modern scientific methods of inoculation against such diseases as typhoid, small pox, and typhus, saved millions from untold suffering and death in the great war. In the present war, and in others that may come, such knowledge will save other millions. Antiseptic and aseptic surgery, and the use of anesthetics, will prevent much horrible suffering and death. Our present scientific knowledge in psychology may restore many victims of shellshock and other mental disorders, as this knowledge is now doing for many victims of past wars or of ordinary accident. Such is the use of the insulin-shock method in the treatment of dementia praecox, for example. Other scientific discoveries, such as the radio, will render life more tolerable to those who will never regain their powers.

I have attempted, then, to run through the whole gamut of war uses of science, and to emphasize that the fundamental scientific discoveries were made for man's happiness and good, rather than for destruction and misery. I have emphasized that the uses for war of scientific knowledge are accidental and incidental, that they cannot be prevented by the scientists, and that blame for misuse is to be placed upon the shoulders of statesmen and of war-makers, rather than upon those of the scientists.

Conklin, in the article I cited above, says:

Science is knowledge of nature and of man, and ethics is necessarily dependent upon such knowledge; it is therefore impossible to divorce ethics from science. But science did not create nature or man or ethics and cannot be held responsible for their imperfections. It is as absurd to attribute human greed, aggression, hate, and war to science as it would be to hold it responsible for hurricanes and earthquakes and pestilences. It is because science regards ethics as a natural phenomenon that it can hope to determine the cause of unethical behavior, and thus attempt to improve ethics by controlling these causes.

Conklin's major thesis is, as I have said, different from that which I wish to emphasize. Yet I may well quote from him certain other passages that illustrate the gradual growth of ethical ideas from a state of savagery: He says:

There is the positive evidence that in times past there were types of human beings that were more brutish in body, mind and social relations than the general average of the present races. There is abundant evidence that ethics has undergone an evolution no less than intelligence. It has developed from its beginnings in a primitive family group through tribal, racial, national and international relations, from the ideals and practices of savagery to those of barbarism and civilization, from the reign of vengeance and retribution, as shown in the ancient code of "an eye for an eye," "a tooth for a tooth," and "whosoever sheddeth man's blood by man shall his blood be shed." This was the iron rule of retribution. Ethics has progressed from this to that highest conception of ethics embodied in the Golden Rule.

Among some savage tribes there is no ethics or altruism that extends outside of the tribe: every tribe for itself and the devil take the others. Their altruism does not go further than that. As one goes up through higher and higher social grades one finds that altruism reaches farther and takes in more people, until with some persons it includes the whole human race.

If we did not know that it is true, it would be incredible that a microscopic egg cell could develop into an elephant or a man. Or, most wonderful of all, that geniuses like Socrates, Plato, Aristotle, Newton, Shakespeare, Goethe, Beethoven, were once babies, embryos, and germ cells; and yet no one denies this. It does seem incredible that reason, emotion, aspiration, and ethics should develop out of such simple functions and processes as sensitivity, reflexes, trial and error, and yet these incredible things are actual facts that can be verified by anyone who will take the trouble to investigate them.

In general, development is a gradual process, but we recognize that there are stages when it passes from a lower level to a higher level by the process of emergence. Finally, the highest level of human development is attained when purpose and freedom, joined to social emotions, training, and habits, shape behavior not only for personal but also for social satisfactions, for society no less than the individual is seeking satisfactions, and when these things combine, we have what we call ethics, or the science of right conduct. Thus ethics is born and man becomes a free moral agent.

War tends, indeed, always to break down ethical standards and to reverse the gradual increase of them through the painfully slow evolution which Conklin traces. That other terrible

breakdown of ethics which has occurred in Europe even before the present war adds mightily to a danger of return to savagery, and to the ethics of savagery.

My own major contention—the burden of what I wish to say to you today—is that science, far from contributing to war or to ethical breakdown, stands today at the forefront of ethical progress and of the maintenance of the highest ethical standards that the race has yet attained.

Let me review with you some of the most fundamental principles of scientific work, and of conduct of scientific men of this age. I have said that *science* stands first of all for a free search for *truth*. If any scientist should indulge in pretense, or in the slightest deceit regarding either his methods or his results, you know that he would stand disgraced and forever ostracized by his fellows everywhere. Is there any other group of people in our nation or in any other nation that holds so high a standard? I will not ask you to think of what are called “*bad*” politicians, or “*bad*” lawyers, or “*bad*” business men. Think, if you will, of the better element in any such group, and ask whether their condemnation of—let us say—a failure to state something which they know which is contrary to their contention, would even approach the utter contempt of the scientist for such concealment. Not even among professed leaders of public morality is there so high a standard of *truth*, such harsh condemnation of *deceit*.

A second fundamental principle of science to which all modern scientists subscribe is *service to mankind*. No other motive is so compelling for any true scientist: not *gain* for *himself*, for his *institution*, even for his *nation*, compares in his mind with *service to mankind as a whole*. I think of a very recent instance—a remark by E. O. Lawrence of Berkeley, who was awarded the Nobel Prize in Physics this fall for his invention of the Cyclotron. Upon learning of this honor, almost his first remark is said to have been: “Well, now, that money”—(it is \$40,000)—“will be a fine down payment on a larger Cyclotron!” There is no thought of his own gain, but only that this may enable him to do still more effective work toward the extension of the benefits to mankind which the Cyclotron has made possible. Such is a typical attitude of the true man of science. Is there any group of men otherwise, any nation, any creed, which has so high a standard of unselfishness, so strong a motive toward the *benefit to mankind*?

The third fundamental principle of all modern scientific work is that the results achieved shall be made at once available to all scientists throughout the world. This stands for a real belief in the *brotherhood of man*, which is on a high ethical plane. It was not always so; in the middle ages, even scientists attempted to prevent other scientists from knowing their methods and their results. You will remember that many instances exist of anagrams so constructed that a scientist of that age could afterward prove his claim to a discovery, but so that no other scientist could read it. All that is gone. The only vestige of it is in the scientific research departments of great industrial companies, where discoveries are regarded as the property of the firm until permission to publish is given. That restriction is by commercial managers, however—not by the scientists who make the discoveries. In this principle of brotherhood among all scientists, as in the other two principles, I believe that scientists as a group are unique: no other group of men, no creed, no nation has actually practiced to such a degree the doctrine of the brotherhood of man.

These three principles—the free search for truth, the service to mankind, the brotherhood of all mankind—are among the highest ethical principles. They are frequently stated as theoretical doctrines by those outside of science. Their actual practice by a large group of men is realized today by scientists the world over. They constitute a body of ethical doctrine which would place the world on a higher plane of civilization if they could be accepted and practiced by other groups, and by whole nations. I believe that this will come, in time.

Such a body of ethical doctrine comes very close to that of the best religions. I have lately emphasized to groups of churchmen that the fundamental problem of science is always search for truth, and that no true religion can be opposed to such a search. Only the pseudoscientist is interested in any other thing, or in denial of any religious tenet that does not conflict with truth. Only the fanatic in religion is opposed to search for truth or in the maintenance of any tenet that conflicts with truth. For either scientist or religionist to violate what I have just said would be, in itself, unethical and unmoral in the highest sense of that word.

In his article already cited, Professor Conklin says:

Probably the most important ethical and religious code in history is the Decalogue of Moses, which was summarized by Jesus in two great

commandments: "Thou shalt love the Lord thy God with all thy heart, soul, and mind, and thy neighbor as thyself." If for the person of the Deity there be substituted the qualities of Deity, namely, truth, justice, mercy, love, these are the commandments of science as well as of religion. Likewise the Golden Rule is the simplest and at the same time the most universally practicable rule of ethics ever proposed.

Would that all men, all nations, would learn to believe and to practice, as do men of science, the essential principles that I have stated!

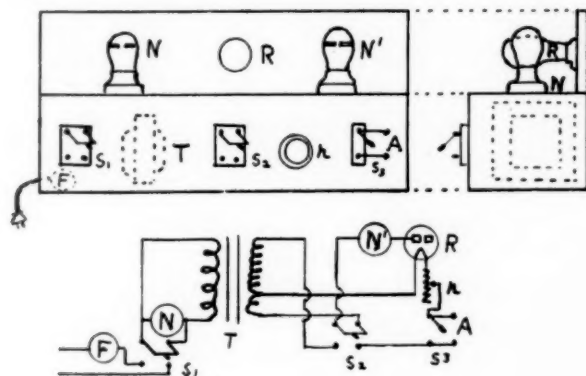
The hope of the world, if ever this savage period in which we live shall pass, is that such ethical principles shall guide, so that wars shall cease, so that swords may be beaten into plowshares, so that every discovery of science shall be used only for the good of mankind, and not again misused, abused, perverted to his misery.

### DEMONSTRATING THE PRINCIPLE OF THE RECTIFIER

F. W. MOODY, *Cleveland High School, St. Louis, Mo.*

The assembly shown here is designed to give visual demonstration of the action of a rectifying tube in changing from A.C. to D.C.

The 110 volt A. C. source connects through fuse  $F$  and switch  $S_1$  to the primary of transformer  $T$ . A neon bulb,  $N$ , having two semicircular disks, is shunted across the primary circuit. Both disks of this lamp glow.



When switches  $S_2$  and  $S_3$  are closed, the rectifying tube,  $R$ , functions<sup>1</sup> and one disk only of the neon bulb,  $N'$ , in the plate circuit, glows. Resistance ( $r$ ) regulates the strength of the filament current. By inserting an ammeter at  $A$  and opening switch  $S_3$ , the current in the rectifying tube may be adjusted to its proper amount.

The secondary of transformer,  $T$ , supplies current for both filament and plate. The large sketch gives a top view of the outfit.

## PHOTOMICROGRAPHY—A PROJECT IN BIOLOGY

GEORGE H. HAMILTON

*Lecturer in Biology at the Niagara Parks Commission's  
School for Apprentice Gardeners*

and

*Teacher of Biology, Niagara Falls Collegiate Institute*

In order to make the course in Biology more interesting, it is necessary to give the students as much opportunity as possible to gain experience in the use of the tools of this science. Most teachers of Biology have their classes carry out some simple experiments and observations on the growth and anatomy of plants and animals. Such work is very advantageous; but even more important is the recording of such observations.

Today, all Biology classes in the more progressive secondary schools make constant use of the microscope. Large portions of the laboratory periods are devoted to having pupils examine stained microscopical sections with this instrument. Usually their findings are put on paper in the form of suitable drawings. In actual practice, however, biologists prefer the more exact method of photomicrography. There are few published papers in Botany, Zoology, Bacteriology or the many allied branches of Agriculture and Medicine, that are not illustrated with some photomicrographs. With these things in mind, the writer felt that some training in the various steps involved in the preparation of photomicrographs was necessary.

Last Christmas, the school camera club decided to build an enlarger. The essential equipment required was a double-extension, plate-back camera; which was purchased from a second-hand shop for five dollars. (This camera, with its 7.2 lens, might seem an unusual bargain, but one store visited had sixteen suitable cameras priced from seven to twenty dollars.) As an enlarger unit, it gave excellent service; and as the camera was easily detached from the enlarger lamp house, it served equally well for useful demonstrations in the making of photographs of insects and photomicrographs. This point is mentioned here to show the value of the camera in the school. The rest of the equipment required can be easily obtained from the supplies of the school Biology or Physics stores, or quickly devised to fit the needs of the experimenter.

In setting up the apparatus, it was found necessary to make a permanent coupler to hold the microscope and camera in their

correct positions. In the one end of a block of wood,  $1\frac{3}{4}$  inches square by  $1\frac{5}{8}$  inches long, a hole  $1\frac{3}{8}$  inches in diameter and  $\frac{3}{4}$  inches deep was bored. This just accommodated the camera lens-collar. In the other end of the block, a hole  $1\frac{9}{32}$  inches in diameter was bored through the length of the block. With a knife and sandpaper, the interior of this wooden coupler was tapered off. This was then lined with black velvet, which prevented any leakage or reflection of light. (If the velvet is pasted on to paper first, it can be more easily inserted into the tube.) (See Fig. 1.) Temporary couplers can be easily made with a cardboard tube or strips of black electric tape.

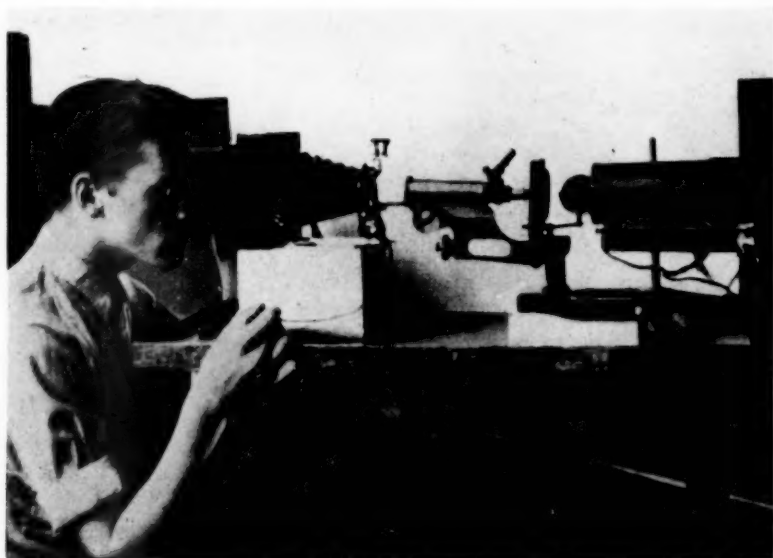


FIG. 1. A student demonstrates the operation of the photomicrography equipment.

When taking a photomicrograph, bringing the lens of the camera and the ocular of the microscope together, holding them in place by means of the wooden coupler. Then the material to be photographed is mounted on the stage of the microscope and the light turned on. The photograph may be made by light reflected from the mirror, or by sending the light directly through the aperture in the stage.

Focusing is a very important step, since the quality of the picture obtained depends greatly upon the care taken in this detail. The focusing was accomplished by manipulating the

coarse and fine adjustments on the microscope at the same time viewing the image on the ground glass at the back of the camera. When the image was most clear, the ground glass was removed and film or plate substituted. The only thing that remained to do, was to give the required exposure. It should be noted that a film-pack adapter is perhaps easier to work with since it allows twelve photographs to be taken with a minimum of change and equipment.



FIG. 2. Photograph of a moth (*Samia cecropia*).

Pupils should be encouraged to follow the process through to its conclusion. It is an easy matter to take the class to the dark room where the actual developing and printing are carried out. Usually student interest has been aroused to such a pitch that all are anxious to have a share in doing some of the numerous tasks, such as getting the developer and fixer ready, developing, printing, mounting, etc. No doubt a great deal of this grows from the desire to see the results of their previous work in the class room. Half tones of photomicrographs made by pupils accompany this article.

In carrying out photomicrography in the Biology laboratory, the instructor should note some of the following points:

(a) *Camera*: It is possible to adapt almost any type of camera to this work. An ordinary box camera, if provided with a ground

glass back, will give remarkably good results. Naturally, greater facility and better photos are obtained with an extension camera having a film-pack adapter.

(b) *Microscope*: There are few schools which do not possess a microscope. The better equipped schools try to provide at least one microscope for every two pupils in the senior Biology class. Almost any make of microscope will prove suitable for demonstrations in photomicrography. Some surprisingly good results have been obtained by holding a small hand lens in front of the camera lens. One should not attempt to get too

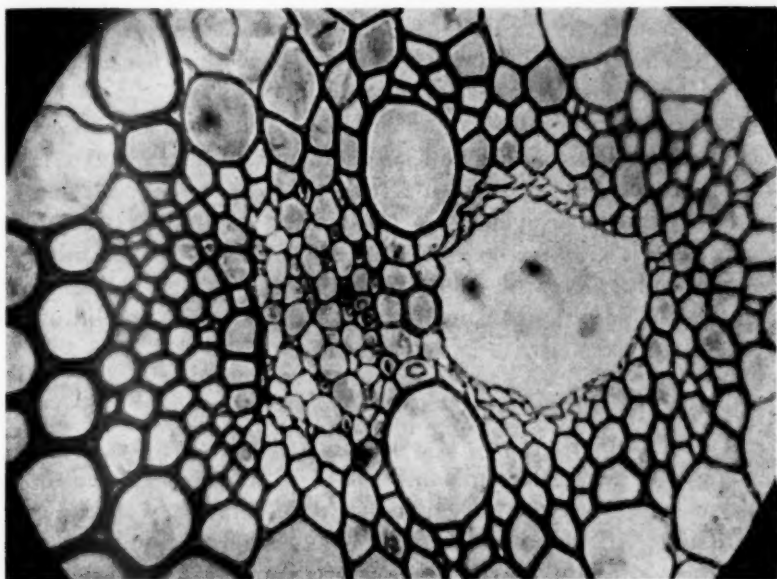


FIG. 3. A cross section of a vascular bundle of the corn (*Zea mays*).

great magnifications, as there is a serious loss in definition beyond  $500\times$ . The limit will naturally depend on the equipment at the teacher's disposal.

(c) *Light*: Several sources of light were tried, with varying results. The best means of lighting was obtained by using a beam light which belonged to the equipment of the Physics laboratory. This light used an ordinary car bulb and allowed for some variation in intensity, being supplied with a rheostat. The obvious advantage is that it gave a light of constant intensity, when so desired. This allowed for proper calculation of the exposure necessary for each photomicrograph. Equally

good results have been obtained with an ordinary 100-watt bulb. Daylight, when strong enough, can also be utilized. In order to assure an even light over the whole slide area to be photographed, it was found advisable to use a piece of ground glass to diffuse the light from the beam or bulb—the ground glass being placed between the source of light and the microscope. The specimen material can be illuminated by light reflected from the microscope mirror or by shining the light directly through the aperture. This latter method was found to be the more convenient.

(d) *Film and Fillers*: This phase of the experiment has not been exhaustively explored. The best results were obtained using Orthochromatic film. Proper exposure time can be ascertained by exposing small sections of one film for  $1/25$  to  $1/50$  of a second intervals. From the developed film, the desired density can be selected and subsequent exposures given the required time. Using a green filter between the source of light and the film gave even more contrasting results, particularly with plant sections which contained areas stained red. Filters were simply pieces of colored cellophane through which the light passed. No doubt some interesting results can be obtained from further trials with light of various colors.

#### *Summary and Conclusions*

(1) Photomicrography is a valuable aid to the teaching of Biology. It interests pupils and furthers their appreciation for this science. They get a clearer picture of what they should see on a slide. Above all they learn considerable technique which may prove invaluable to those who pursue advanced studies in any of the sciences.

(2) Photomicrographs are excellent for demonstration purposes. An album in which these are mounted will prove an excellent addition to classroom equipment. It can be passed around and particular photomicrographs used to demonstrate the lectures.

(3) Photomicrography is inexpensive. Ten dollars should provide all the necessary equipment and give as well, a sufficient supply of film and chemicals for the first year's work. After the equipment has been paid for, the cost is governed by the number of times that the experiment is conducted.

The author would appreciate receiving the comments of other teachers who attempt this interesting and instructive project.

## THE FUTURE OF SPECIALIZED SCIENCES IN HIGH SCHOOLS\*

SHERMAN R. WILSON

*Northwestern High School, Detroit, Michigan*

Last year, at the Annual Convention of the Central Association of Science and Mathematics Teachers we were discussing plans for a science program. At that time I called attention to the fact that the specialized sciences are in danger of being crowded out by the social studies and that a sort of glorified general or integrated science may take the place of chemistry and physics. If this happens it will be a serious mistake. Our science program will be badly handicapped. It may take years to regain what we have lost. This is no "false alarm." The social studies are still going strong, and, in several parts of the country, these integrated courses are springing up like mushrooms.

Perhaps you may not see the danger. You are a specialized group. You know that chemistry and physics have been taught in our high schools for more than fifty years. You know the value of these subjects and you may feel that their future is secure. But what are the facts? Statistics show that the percentages of the total number enrolled in standard science courses have been falling off. At present only about seven per cent are taking physics and chemistry. And, if this integrated idea keeps up, we may all be teaching scrambled science.

Perhaps some one may ask—"What is integrated science?" The name is not well-chosen. In my opinion these courses are, as a rule, neither integrated nor scientific. Frequently they contain general information that can be found in current magazines or in pamphlets put out by some industrial firms, such as General Motors and General Electric. In these integrated courses, fundamental principles are considered of minor importance, and little attempt is made to show how these principles are applied.

For example, let us take soap. To understand how soap is made the student must know something about neutralization. And, to understand how soap cleans, he should have studied solutions and emulsions; he should also know something about hydrolysis and the properties of free alkalies. In an integrated

\* Paper presented to the Chemistry Section of the Central Association of Science and Mathematics Teachers, November 1939.

course, however, these fundamentals are often omitted. Instead, different kinds of soap may be discussed and several brands compared; but, as a rule, more up-to-date information can be obtained by reading the *Consumers' Guide* or other government reports.

The question naturally arises, why should there be any demand for simplified courses in science? I think we all recognize two reasons for this demand. First: The average intelligence quotient of our high school students has been *decreasing* while the amount of material in our standard textbooks has been *increasing*. Second: There is a growing demand for consumer education.

To illustrate my first reason let me tell you about an educational conference recently held in Detroit. About 700 high school teachers met to discuss current problems in education. More than forty problems were presented, varying from "Extra Curricular Activities" to "How to Save the World for Democracy." But the topic that met with universal approval was—the problem of *teaching pupils how to read*. Here is a need that we all recognize. Before he can learn chemistry a pupil must know how to read; and, in order to master our standard courses, he should be able to add, subtract, multiply and divide. Some of us have seen the educational pendulum swing back and forth. Recently the tendency has been to try to develop "happy citizens." Some have interpreted this to mean "Let the children do as they please." Too often they choose to do nothing but play. Now we are suffering the consequences. A reaction is sure to follow. The public will demand that we get back to the fundamentals.

But what has this to do with the specialized sciences? Very much, indeed. We are now in danger of following the popular trend: of taking the easy way: of letting the child decide what he needs. What can we do about it? Shall we force all of the pupils to take the standard courses? Evidently this would be wrong. We must recognize differences in ability.

In Detroit we are using a two-way plan. The college preparatory students take the standard courses in biology, chemistry and physics, and, for the general group, we have developed what we call descriptive courses in science. In the 10th grade we offer descriptive biology and in the 11th and 12th grades we teach descriptive chemistry and physics. The aims of these special courses are:

First: To develop some appreciation of the importance of these sciences; to every citizen, to every homemaker and to every consumer. Second: To teach fundamental principles and to fix them in mind by demonstrating them and by observing their applications. Third: To develop the scientific or open-minded attitude, as opposed to the narrow-minded prejudice which is all too prevalent.

Perhaps a word about the content or subject matter in our science courses for general pupils would not be out of place. In some respects it is similar to that found in the standard textbooks. Fundamental principles come first; the applications are grouped about them. But, in *Descriptive Chemistry* we omit all the drill work on valence, the balancing of equations, and the development of formulas. This gives us more time for such topics as:

Foods: bringing out the importance of vitamins and minerals in the diet.

Fuels: coal, oil, and gas: discussing the problem of conserving our natural resources.

Drugs: their sources and uses, and also warning against fakers and dope peddlers.

Cosmetics: their use and abuse, and how to develop a sales resistance.

Clothing and Cleaning Agents: Chemical tests to detect frauds, and how to remove spots and stains.

Building materials: cement, glass, metals, and alloys. In general, topics that are of every-day importance.

In physics, the applications are even more abundant. Every time we turn on the lights, make toast, start the car, listen to the radio, use the telephone or any of the hundreds of electrical devices, we are making use of applied physics; and, in studying sound, heat, light, and mechanics, the applications are too numerous to mention.

But let me make this point clear; these every-day applications are used to illustrate fundamental principles. They are not scrambled together all in one chapter as is frequently the case in integrated courses. We teach chemistry one semester and physics the next.

Some may contend that the survey or integrated courses are better suited to the needs of consumers. There is no evidence to support this contention. A textbook may give much information about last year's model or product; but will such information be of any value five years from now? On the other hand, if we teach fundamental principles and the scientific method, these principles and this method will be good for a lifetime.

And, when we are trying to teach the scientific method, let us

not forget the value of laboratory work. During the depression we have been compelled to cut down the number of hours in the laboratory. As a result our students have been handicapped and some of them have failed in their science classes in college. Unfortunately there is a tendency to eliminate all laboratory work for the non-college group. From the standpoint of economy this may seem to be necessary, but we all know that slow-learning pupils need the concrete experiences that individual laboratory work affords.

During the last school year we have been conducting an experiment that tends to prove this statement. We asked for volunteers in our non-college classes, and a number agreed to stay an extra period for this special laboratory course. To make the work more worthwhile, we let these students test materials in which they were personally interested. To illustrate, I will give a few examples. When we were studying weights and measures, the pupils brought in queer-shaped bottles and measured them. They were impressed when they found that some bottles looked twice as large as they really were. Then we weighed peanuts purchased from a slot machine and found that we were paying 50 cents a pound for 15-cent peanuts.

Next, we studied mixtures and tested scouring powders and tooth paste. While we were studying acids, bases and salts in the textbook, we tested ammonia and vinegar in the laboratory. Later, pupils in our descriptive physics classes tested thermometers, antifreeze mixtures, lubricating oils, and other products. In every case, however, the experiment was used to illustrate and to fix in mind some fundamental principle. They were not just testing things. They were learning. They were applying the scientific method. We are now developing these consumer tests into the form of a workbook to be used in connection with our descriptive courses for the non-college group. Doesn't this experiment suggest one way to improve the future of our specialized sciences?

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#### MATHEMATICS PRIZE AWARDED

For solving a famous and difficult problem in mathematics, concerned with what are called Riemann matrices, Prof. A. A. Albert of the University of Chicago was presented with the Cole prize, awarded by the American Mathematical Society once in five years.

## SOME PROBLEMS CONFRONTING THE TEACHER OF GEOGRAPHY

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### OUR AMERICAN AIM OF EDUCATION

This age in which we are now living is sometimes called "the problem age," not only because of the many important problems which are confronting us, but also because man has been taking a very active interest in solving them. Problems have always faced the people of the world and as long as there are human beings there will be problems. Our problems become more complicated as we advance along the road of civilization, but we must also remember that our power for solving problems becomes greater. As long as we make progress towards correctly working out our problems, we are advancing, but woe to us if the time should ever come when our problems are too difficult for us to solve. A study of the history of mankind teaches that the decline of peoples and nations has been due to the lack of ability to solve successfully the problems which confronted them.

Every person who is capable of thinking is capable of solving problems. There is an unlimited number of problems, some of which are of great importance. Probably all of us would not agree on what is the greatest problem confronting the American people today, because our past experiences teach us to look at things in different ways. However, I believe that all of us would agree that one of our great problems is the proper education of the boys and girls and the men and women of our land. I include men and women because a person is always being educated to a greater or less extent as long as he receives stimuli which influence his actions.

Now, what is the chief idea or aim in the proper education of our people? It is the forming of good American citizens. Or to express the thought in another way we might say that the chief aim of education is to get our people to understand the meaning of and to practice American democracy. In our American democracy problems are settled in the democratic way. People think for themselves in place of having their thinking done for them by a dictator. They are encouraged to come together to discuss their problems in place of being forbidden to have

discussion, so that changes may be made by persuasion and not by force. Individual initiative is developed because in our American democracy it is realized that each individual must have the opportunity of giving to society the best that is in him. At the same time, the individual respects all other persons and he cooperates with them in the true American way for the betterment of society.

All the subjects in the curriculum contribute to the proper education of our people, but some subjects have much more to contribute than other subjects. Undoubtedly the social studies occupy a leading place in the curriculum, because they furnish many of the experiences which our students need for forming the correct ideals, habits, attitudes, and desires which all good citizens must have. In fact, many educators claim that the social studies should occupy the most prominent place in the curriculum. Since geography is one of our chief social studies, one can easily see the important place which geography occupies in American education.

In teaching geography, many problems confront the teacher from time to time. The problems naturally fall into the following two groups: (1) those problems which can be answered with little difficulty or are of minor importance and (2) those problems which are of major importance and require much research, experimentation, and thinking before they can be answered satisfactorily. Very often some of the problems of this last group cannot be answered as definitely as we might wish. Let us consider four of the important problems which every teacher of geography must consider carefully many times while he is teaching geography. These problems are ever with us and the answers which we have for them today are not exactly the same answers which we will have for them tomorrow. As we grow in power to teach and to understand problems, our ability to answer them will be greatly enhanced.

#### WHAT GEOGRAPHY SHOULD I TEACH

One problem which every teacher of geography must consider is "What geography should I teach my students?" In thinking about this problem, many questions will arise. Should we strive to get our students to learn certain facts and to accumulate a certain amount of knowledge? We often hear it said that we should not teach facts, but we should teach our students to think. But we ask, how can a student think accurately and

intelligently if he cannot recall facts? Do not we have too much loose thinking among the American people today and is not much of this loose thinking due to the fact that the people lack accurate data on which to base constructive thinking? Is it not possible to teach our students to accumulate knowledge and to learn to think at the same time? Our students should come to understand that a well informed person is a greater asset to our American democracy than a poorly informed person. They should be led to see that an informed person does not spend very much of his time in guessing what might be true, but he seeks to obtain accurate knowledge so that he knows what is true. Without doubt, there is a body of useful geographic knowledge which every student should have at his command when he finishes his work in high school. Students should gradually accumulate this knowledge not in any one grade, but in all grades. From the time the child enters the lowest grade in school until he finishes the highest grade he should gradually be gaining geographic information and experiences which will aid him in solving his problems. The geographic knowledge which a student learns should be used again and again in different situations. Why is it that a student forgets many of the things which we think he has learned? It is because many of the things are never used by the students in solving new problems. The brain is not a storehouse for useless facts and it is a waste of time to expect students to store up knowledge which will be of little use to them.

Just what geographic knowledge should a student have when he graduates from high school? He should have enough geographic knowledge of his own country and of the other countries of the world so that he can interpret intelligently where people live, why they live there, and how they live there. Or in other words, he should have a knowledge of the ways people live, work, and spend their leisure time in various parts of the world; and why they live, work, and spend their leisure time as they do.

On leaving high school a student should know something about the importance of farming, mining, manufacturing, lumbering, grazing, hunting and fishing, and carrying on commerce in each region and country. He should have some knowledge of the social and political activities in each region. He should know something about the elements of the natural environment, such as area, location, climate, surface, soils, water bodies, minerals, plant life, and animal life in each region and the part

which each element plays in the life of man. He should have an understanding of how human activities are influenced by the natural environment. He should know that the natural environment plays a great part in the actions of men. By understanding the elements of the natural environment in any region, a person will have some of the data which will enable him to interpret events as they occur. Why are some nations seeking to expand? Why are some nations apparently satisfied to remain as they are? Why do nations carry on trade with one another? These questions and hundreds of similar questions confront us every day and a certain amount of geography, as well as other information, is needed if such questions are to be answered correctly.

In studying about countries and regions, a student will learn the location of important places throughout the world. If a place is of enough importance to study, it is of enough importance to locate. A given place has more meaning to a person if its general location on the earth is known. Just how many places should a student be able to locate in a general way on leaving high school? No one knows the correct answer to this question. We do know that it is a waste of time to teach the location of places as isolated facts. Places are located when there is some good reason for locating them.

Every student on leaving high school should have a knowledge of the conservation of our natural resources. Our chief natural resources are soils, waters, minerals, forests, grass lands, and wild animal life. By conservation is meant the wise use and the avoidance of waste, and wherever practical, restoration and perpetuation. The United States is the greatest country on the face of the earth, chiefly because it is blessed with an abundance of natural resources. The future of our country depends largely upon the conservation of our natural resources. If we want our country to keep on making progress and to occupy the high position which Nature evidently has intended it to occupy, each one of us must believe strongly enough in conservation to practice it. Hence, our schools must teach conservation and they must instil in the minds of their pupils the desire to practice conservation.

#### WHAT METHODS SHOULD WE USE

A second question which confronts the teacher of geography is "What is the best method in teaching geography?" During recent years many different methods have been used. We have

heard or read about the textbook method, the question and answer method, the argumentative method, the discussion method, the story and lecture method, the imaginary journey, dramatization, the topical outline, various forms of individual work, including the laboratory method, problems and projects, the unit method, the activity method, and various other methods. New methods or ways of teaching are being discovered from time to time. Some of the methods are closely related to one another. Teachers often use parts of various methods in teaching. No one teacher has a monopoly on the best method to use. Every teacher should make his own method. He should plan his work so that there will be no guessing on his part about what plan or method to use.

There is no one general best method in teaching which should be used by all teachers. The method that is best suited for one teacher is not necessarily the best method for another teacher. Each good teacher is an individual who knows how to teach. He makes his own plans for teaching. He studies the various methods which other teachers use. He gets ideas and suggestions which he combines with his own ideas in order to form his own method of teaching. Thus, each teacher determines the method which he is to use. Whether it is a good method will depend upon the results which his students obtain. If a teacher finds that his method is a poor one, he should not hesitate to discard it and to adopt a better one.

Each teacher should strive to improve his method from day to day. The best method today will not be the best method tomorrow, because as a teacher grows in the power of teaching, his methods are bound to change to a certain extent. Every teacher should carry on a certain amount of experimentation in order to find a better way of teaching. He should have the feeling that there is a better way of teaching which is yet to be discovered. Whenever a teacher is perfectly contented with the methods he is using, he is no longer making progress.

A teacher should feel free to use different methods from time to time. One unit may be taught best by using one method, while another unit may be taught best by using a different method. Again, if one method is used continually, the students may get tired of studying geography. Variety is sometime said to be the spice of life and this is as true in teaching as it is in any other aspect of living.

### HOW SHOULD TOOLS AND OTHER MATERIALS BE USED

A third problem which confronts every teacher of geography is "How should tools and other materials be used in teaching geography?" By tools and other materials we mean textbooks and other printed materials, the radio, maps, pictures, graphs, charts, objects, exhibits, museum materials, and models.

Most teachers prefer to use textbooks in teaching geography. Some educators condemn the use of textbooks. However, many educators believe that textbooks should be used by the great majority of teachers because (1) of the lack of geographic knowledge on the part of many teachers and (2) of the lack of an abundance of reference materials in the schools. A good textbook gives information on many of the units which are to be studied, it helps the pupils and teacher to organize the work, it furnishes material which all the pupils may study, and it is very useful in making summaries and reviews.

Authors could write better and more useful textbooks if there were a general agreement on what material should be taught in geography in the different grades. During recent years, many schools have written new courses of study in geography. In many cases it seems as if a school has tried to make a course which is different from courses in other schools, because of the mistaken idea that it shows lack of progress to use the same organization that is used elsewhere. Would it not be a step in the right direction if there were a reasonable agreement on the course of study which should be used in the different grades?

American schools have the best textbooks in geography that are to be found anywhere in the world. They are highly illustrated with maps, graphs, and pictures. Many of them have various kinds of aids which help the pupils in studying. However, no matter how good a textbook is, teachers are needed to see that the pupils know how to use it efficiently. Teachers must see to it that unthinking memorization is not one of the results of using a book. They must make sure that the textbook is written in language that the pupils can understand. Pupils must be taught how to use their textbooks wisely in studying their units of work. Whether the textbook is used wisely or unwisely by the pupils depends largely upon the experience which the teacher has had in the use of textbooks.

Even though textbooks are used, teachers should encourage pupils to read reference books and other supplementary material. The amount of collateral reading that pupils do should

increase as they grow older. Collateral reading makes the work more interesting, it adds detail, it gives the opportunity to get different viewpoints, it makes the work more vivid and real, and it performs other important functions which we do not have time to mention here.

What is the best way of using the radio in the schoolroom? No one knows, but many teachers are experimenting and are trying to find out. There is no question but that pupils may learn some geography by listening to certain programs over the radio. Some of the radio programs which have a certain amount of geography are given during school time, but many of them are given outside of school hours. In some cities, a few programs which are related directly to the work of the pupils are given over the radio. We must remember that the radio is only a few years old and that it will take time to understand fully how to make the most efficient use of it in teaching. The coming years will see the radio, and possibly television, assume a very important place in the education of our pupils.

Maps are usually needed when geography is being taught. Every good textbook in geography has many different kinds of maps. Then there are wall maps and other maps which are found in every well-equipped workshop or geography classroom. There are also weather maps, road maps, pictorial maps, various kind of maps in newspapers, and many other kinds of maps.

Should children be taught to use maps or should teachers take for granted, as so many teachers apparently do, that it is not necessary to teach children to read maps. Ask any good teacher of geography this question and the answer will be "by all means teach the children to use maps." A map contains much information. It is something like a storehouse of information which is locked and which can only be unlocked by those who know how to read maps correctly. It is too much to expect teachers to teach children how to use maps, if the teachers, themselves, have never learned how to read maps. Teachers must first have the map habit before they can expect their pupils to have it. Teachers must know what information can be obtained from a map before they can teach children how to use it efficiently. Too many teachers have the idea that about the only use for maps is to locate places. Of course places should be located, but this is only one of the functions of maps.

Pupils cannot learn to read maps in one day or in one set of

lessons. It takes time to get the map habit and to be able to read various kinds of maps. By frequently using maps, pupils gradually learn how to get information from maps. Thus, pupils should begin to use maps in the lower grades and as they advance from grade to grade, their power of reading and using maps will increase. Among other things, upper grade and high school pupils should know how to use latitude and longitude, how to use the scale on a map to estimate distance, and how to use the key or legend on a map in interpreting it.

— Pictures are so common that many teachers never think that pupils must be taught to read them. This is probably the reason why many pupils fail to get very much out of most pictures. There are pictures in books and magazines, wall pictures, photographs, stereographs, lantern slides, strip films, silent motion pictures, and sound motion pictures. A pupil should be taught to enjoy pictures and to get information from them just the same as he is taught to use any geographic tool. Pictures should be used to supplement other educational tools.

Pictures aid in giving pupils correct impressions of the cultural and natural landscape. They help the pupils see objects as they really are. They create interest in the work and they stimulate pupils to go deeper into the subject. Pictures also cause a person to remember something for a longer period of time. Pupils should be taught to get the habit of looking at pictures. They should turn to pictures for help in solving their problems just the same as they turn to the printed page.

#### HOW TO TEST FOR RESULTS

A fourth question which confronts every teacher of geography is "How should the results of teaching be tested?" Tests benefit both teacher and pupil. A pupil has the opportunity of finding out just what he has learned and whether he really understands the subject. He can determine whether his methods of study should be changed. He can see if he is ready to take new problems. He can also learn how he ranks along with other students.

Tests show the teacher how much progress his pupils have made in studying geography. They help him to determine if he presented the material in the correct way and if the pupils have been spending their time in a highly profitable manner. Tests show if the pupils have formed good habits of study. They should also show if the pupils are understanding and practicing American democracy.

Tests may be both subjective and objective. A good test should test for ideals, good habits of work and study, and correct attitudes as well as for information. It is probably true that many of our tests measure information in place of measuring the other elements which go to make a good citizen. Some tests may be oral, while others are written. Some tests may be short, while others may be reasonably long. Tests may involve a certain amount of activity work, other than writing. As a teacher grows in experience and understanding, he gains in the ability of giving the right kind of tests at the most opportune time to his students.

#### CONCLUSION

In concluding, we will again repeat that a progressive and energetic teacher of geography is always confronted with many problems. He is continually asking himself if there is not a better way than the one he is using. He is always seeking to find new methods and to train his pupils more efficiently. He is never entirely satisfied because he knows that no matter how good the results are, they might have been better. Yet the teacher is an optimistic individual. He firmly believes that through his efforts and the efforts of thousands of other teachers the boys and girls of our land are receiving the kind of education which will cause them to be better citizens and to appreciate more fully the meaning of American democracy. The kind of education which the boys and girls receive today will help to determine the kind of citizens they will make in the future.

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#### ANNOUNCEMENT OF THE ANNUAL MEETING OF THE NATIONAL COUNCIL ON ELEMENTARY SCIENCE

The National Council on Elementary Science will hold its annual meeting in St. Louis on February 24, the Saturday preceding the meeting of the American Association of School Administrators of the National Education Association. The meeting will be held in the Crystal Room of the Jefferson Hotel.

This organization is offering a very excellent and stimulating program. The entire program will deal with science in the elementary school. The morning session will consist of papers given by Dr. Otis W. Caldwell of Boyce Thompson Institute of Yonkers, New York, and Dr. Florence Billig of Wayne University, Detroit, Michigan.

The afternoon session which is a joint program with the National Association for Research in Science Teaching and the National Council on Elementary Science, will consist of papers by Dr. Gerald Craig of Columbia University and Dr. Martin Robertson of New York University. After these two papers, Dr. Craig and Dr. Robertson will entertain and discuss questions from the floor in a round table discussion.

## A CURRICULUM UNIT ON NON-EUCLIDEAN GEOMETRY

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### INTRODUCTION

The aim of this unit on non-Euclidean geometry is twofold. On the one hand, it is intended to emphasize, in as striking a manner as possible, that the conclusions of any logical argument depend upon the assumptions which form the basis for that argument. On the other hand, it is hoped that it will suggest to the student new areas of interest to explore.

It would be difficult to devise a better way of showing that conclusions depend on the assumptions made than to do as is done in non-Euclidean geometry, simply change some of the assumptions and see what changes in the necessary conclusions follow.

Too long it is that geometry has been regarded as a sort of sight-seeing trip into the thought pattern of ancient Greece. No attempt has been made to open up any vistas of new regions to be investigated because the science of geometry has been regarded as complete.

It is intended that this unit be used in connection with a geometry course in which the method of approach suggested by Fawcett<sup>1</sup> and Ulmer<sup>2</sup> is used. It should help to make certain that the student realizes the tentative nature of geometrical "truths" and to afford a glimpse into the more recent geometrical developments. If care is used in bringing out some of the conflicts between theoretical geometry and the physical world throughout the regular course, conflicts such as those suggested by the questions in the text of this unit, it should be possible to make this material a component part of the regular course in geometry as taught at present.

The suggested applications at the end are intended merely to indicate a means of integrating the type of thinking required in this subject to everyday life. Countless variations and improvements will suggest themselves.

Bibliographical references have been largely omitted since

<sup>1</sup> H. P. Fawcett, "Teaching for Transfer," *Mathematics Teacher*, 28: 465-72, December, 1935.

<sup>2</sup> Gilbert Ulmer, "Teaching Geometry for the Purpose of Developing Ability to do Logical Thinking," *Mathematics Teacher*, 30: 355-57, December, 1937.

most of the source material is not suited to the comprehension of high school students. A representative bibliography is appended for the use of teachers.

#### A UNIT ON NON-EUCLIDEAN GEOMETRY

What is a straight line? It is frequently defined as the shortest path between two given points. Is a straight line always the shortest path between two points? Is there any other shortest path between the two points? If a truth be regarded as something that is always true, then may we accept this as a truth?

When Lindbergh flew from New York to Paris, he naturally wanted to go by the shortest route. Why did he fly north from New York when Paris is east of New York? Why do ships from San Francisco bound for Yokohama sail north past Seattle, Vancouver, and close to Alaska? Is it then correct to say that an arc of a great circle is the shortest path on the earth's surface between two points?

Why do we say at one time that a straight line is the shortest path between two points and at another time that the shortest path is an arc of a great circle? If a truth is something that is always true, is our first definition of the shortest path between two points a truth? Is an arc of a great circle always the shortest path between two points? Is the definition of the shortest path between two points as an arc of a great circle a truth? Or does a definition depend for its truth or falsity on conditions which we assume or take for granted at the start.

What are parallel lines? Would two roads running north and south be considered as parallel? Are the section lines, on which many of our country roads are located, parallel? Then what is the reason for the jog in the road which we find every few miles as we continue north? What is the so-called township correction line?

Is it possible that these roads are not parallel after all? Could they follow meridians and still be parallel? Doesn't geometry state specifically that we can have parallel lines? Then is geometry wrong? Can lines running east and west be parallel? Have you ever noticed that supposedly straight roads—section lines—running east and west, if viewed over a distance of several miles, appear curved? Does that mean poor work by the surveyors? No, the cause of this discrepancy is the same as in the case of the distance between two points. Plane geometry does not fit a curved surface.

Then what is geometry or any other mathematical science? A mathematical science is composed of a set of  $n$  propositions which can be so arranged that if the first  $k$  propositions,  $k < n$ , be accepted without proof, the remaining ones are the conclusions that must follow from those previously accepted. Definitions are merely agreements concerning the meanings of words or terms. A mathematical proof consists in showing that a given proposition is a necessary conclusion if we accept the given assumptions. Mathematics has been termed the science of necessary conclusions. It should be pointed out that by this definition a mathematical proof does not depend for its validity on the truth or falsity of the assumptions. Naturally, however, if the work is to have any application, the assumptions must be in keeping with conditions as we find them in actual experience.

Keeping these ideas in mind, let us investigate the basic assumptions of the ordinary or Euclidean plane geometry. Euclidean geometry takes its name from Euclid, a Greek geometer who lived about 300 B.C., and whose book is essentially the basis of the geometry we study today. Nothing essentially new has been added to elementary plane geometry in 2,200 years.

Euclid began his geometry with a series of definitions, a set of axioms or common notions as Aristotle termed them, and a set of postulates. The axioms, sometimes thought of as self-evident truths, state notions of logic in general. According to T. L. Heath's translation of Euclid's *Elements*,<sup>3</sup> the axioms were stated as follows:

1. Things which are equal to the same thing are also equal to one another.
2. If equals be added to equals, the wholes are equal.
3. If equals be subtracted from equals, the remainders are equal.
4. Things which coincide with one another are equal to one another.
5. The whole is greater than the part.

Could these statements be proved to be correct? Do they seem reasonable? Are they self-evident truths or merely assumptions that seem to square with experience?

Euclid's postulates were statements of the same sort, applied directly to geometry. Altogether, eighteen axioms and postulates are needed to develop the whole of Euclid's geometry. The ordinary text uses many more, taking as postulates propositions which are capable of proof. We need consider for our purposes

<sup>3</sup> Thomas L. Heath, *The Thirteen Books of Euclid's Elements*, I, pp. 221-32.

only the first five postulates of Euclid. These may be stated, simplifying the statements in Heath's translation of Euclid's *Elements* somewhat as follows:

1. Two points determine a straight line.
2. A straight line may be extended without limit in either direction.
3. It shall be possible to describe a circle with any point as center and any distance as radius.
4. All right angles are equal to one another.
5. Through a point in a plane, not on a given line, one and only one line may be drawn parallel to the given line.

Euclid then defined as parallel two straight lines in the same plane which do not meet, however far extended.

From these and certain other assumptions which need not enter into our discussion here, Euclid developed his geometry, showing that, if we accept these assumptions, all the remaining propositions of his geometry must follow as logical consequences. Logically, it seems desirable to keep the unproved assumptions, postulates, as few in number as possible. Hence many attempts have been made to reduce the number needed by proving some of them by means of the others. The last one stated above, the so-called *parallel postulate*, was the one whose proof was most often attempted.

If we consider Euclid's statement of this parallel postulate, the reason for centering these attempts to reduce the number of postulates on it becomes evident. Heath translates Euclid's statement as follows:

If a straight line falling on two straight lines make the interior angles on the same side less than two right angles, the two straight lines, if produced indefinitely, meet on that side on which are the two angles less than two right angles.<sup>4</sup>

We note at once that this postulate is less simply stated and not as self-evident as the other postulates and axioms. Moreover, Euclid proves the following proposition: "If two straight lines have a common perpendicular, they are parallel." Does this proposition seem any less self-evident than the postulate? Does it appear to offer any different situation so far as the requirements of proof are concerned? Since it can be, and is proven, does it not seem that it might be possible to prove the parallel postulate as a theorem rather than assuming it as a postulate? If it is possible to prove it, then why did Euclid leave it as an assumption?

<sup>4</sup> *Op. cit.*, p. 202.

From these and similar considerations, many mathematicians have attempted to prove the parallel postulate instead of considering it as an assumption. The approach most commonly used has been to assume the falsity of the statement and then attempt to show that this assumption leads to an absurdity.

If the parallel postulate is denied, what assumptions could we substitute for it? The possibilities are: (1) that there is more than one line on the point parallel to the given line, or (2) that no line parallel to the given line is possible.

Suppose we take the first assumption, that more than one line parallel to the given line is possible through any given point. Does this lead to any unreasonable results? Can it be shown that this assumption leads to a geometry which explains

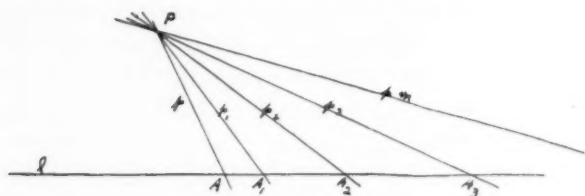


FIG. 1

the spatial relations of everyday life in a manner which is satisfactory as the explanation of the same relations provided by Euclidean geometry?

Suppose we take the line  $l$  and a point  $P$  not on the line. Through  $P$  draw a line  $p$  cutting  $l$  at some point  $A$ . Now let us think of  $p$  as at  $p_1, p_2, p_3 \dots p_n$ . What will happen to  $A$  as this rotation takes place?  $A$  will move out along  $l$  to the positions  $A_1, A_2, A_3 \dots A_n$ . Will  $p$  ever cease to intersect  $l$ ? As  $p$  approaches the position commonly termed parallel to  $l$ , what will happen to the point  $A$  on  $p$  which was on  $l$  until the lines became parallel? Will it suddenly jump away from  $l$  to a distance equal to the distance from  $P$  to  $l$ ? Suppose  $P$  is fifty miles from  $l$ . Will it jump the whole fifty miles "in nothing flat"? Does it not seem more reasonable to assume that  $p$  will cease to intersect  $l$  before it comes to the position in which it is at all points equidistant from  $l$ ? But, if we accept this assumption, we must admit the existence of at least two lines through  $P$  which do not intersect  $l$  and are therefore parallel by the Euclidean definition. One will be parallel at one end of  $l$  and the other will be parallel at the other end of  $l$ . This means

that there will be an angle  $x$  between the two parallels  $p$  and  $p'$  and all lines on  $P$  within this angle are parallel to  $l$ . The Euclidean parallel is merely the special case which is also equidistant from  $l$ .

Again, let us consider the other way of denying the validity of Euclid's parallel postulate. Let us consider the assumption that there can be no lines through  $P$  which do not intersect  $l$ . At the beginning of this unit we discussed some conditions under which a straight line is not the shortest distance between two points. On what kind of surface is this true? What kind of surface is the surface of the earth? Can we have parallel lines on the surface of the earth? Then why have the township correction lines? Remember that the equivalent of a straight line on the surface of a sphere is defined as an arc of a great circle. A

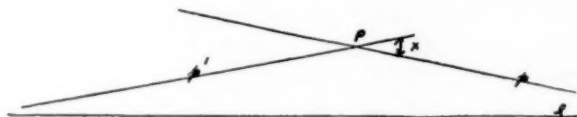


FIG. 2

great circle is defined in solid geometry as a circle on the surface of a sphere whose radius is the same as that of the sphere. Are the parallels of latitude great circles? Are parallel east and west lines on the earth's surface arcs of great circles? In each case the answer is no. Then by our definition of a straight line on the surface of a sphere, these lines are not straight lines. It is proved in solid geometry also that any two great circles on the surface of a sphere intersect. This means that under our definition of a straight line on a spherical surface, there can be no parallel lines on the surface of a sphere.

Now the surface of the earth, as we experience it, is a plane. Yet we know that the above ideas are true of lines on its surface. Is it too difficult to conceive of a plane surface having the characteristics of a spherical surface? On such a plane surface, lines would be closed curves; finite in extent, analogous to the great circles of a sphere. There would be no parallel lines, as every line would intersect every other line.

Keeping these ideas in mind, we are ready to consider the validity of Euclid's geometry and the possibility of other valid geometries. It is, of course, obvious that our previous discussion

has proven nothing regarding the truth of the various stated assumptions. We have only pointed out some of the implications involved in accepting or rejecting various assumptions. But, in the light of this discussion, the question certainly arises as to whether the conclusions reached by Euclid are valid, and under what conditions they must be accepted as valid. Are valid geometries, different from Euclid's, possible?

Euclid's conclusions are valid if, and only if, we admit his assumptions. They must be accepted only if we accept his assumptions. There are other valid geometries, based on assumptions different from those of Euclid, which are true in the same sense that Euclidean geometry is true; in that they correctly describe space having the characteristics set forth in their basic assumptions.

The first of these geometries is based on the first possible alternative to Euclid suggested above—that an infinite number of lines may be drawn through a given point parallel to a given line. It was developed independently about 1830, by a Russian, Nicolai Lobatschevski, and a young Hungarian army officer, Johann Bolyai. This geometry accepts all the Euclidean assumptions except the parallel postulate, and in its place makes the assumption that within the limits of a finite angle<sup>5</sup> any line on a given point is parallel to a given line.

The other possibility—that no lines parallel to the given line are possible—forms the basis of Riemannian geometry, developed by Riemann about 1850. He also discarded the conception of a line as being infinite in length, considering it as a closed curve. The Riemannian plane is analogous to the surface of a sphere and has the characteristics suggested in our previous discussion of that possibility. It is the geometry on which Einstein based his theory of relativity.

Are these geometries true? If we accept the definition of a mathematical science as stated earlier in this unit, they are true because the conclusions follow logically from the assumptions and do not lead to contradictions. Are they true in the sense that they "work"—that they can be used in everyday affairs? Any of the three would serve equally well as the basis for designing buildings, bridges, and other engineering structures. As Keyser points out in the chapter on non-Euclidean geometries in his book, *Mathematical Philosophy*,<sup>6</sup> structures

<sup>5</sup> See angle  $x$  in Figure 2.

<sup>6</sup> C. J. Keyser, *Mathematical Philosophy*, chap. XVII, pp. 342-65.

whose design and construction were guided by the non-Euclidean geometries would not differ perceptibly from those built by Euclidean geometry. Keyser explains this by saying that although the formulas based on any one of these geometries differ radically from the corresponding formulas based on the other two, the differences are such that they become important only in physical structures vastly larger than those possible on our small planet.

All three of the existing geometries then meet the requirements of a valid mathematical science. They meet the needs of everyday life; hence are equally valid. Then why teach and use the Euclidean in practical work exclusively? It is simpler; easier to use and equally accurate. But, as we have seen, Euclidean geometry does not fit the needs of the surveyor and navigator. Neither will other plane geometries. The earth is a sphere. Our difficulties in surveying come from attempting to fit plane conceptions to a spherical surface.

As pointed out both by Keyser in the book mentioned above, and by Roberto Bonola, in his book *Non-Euclidean Geometry*,<sup>7</sup> there are no surfaces in ordinary space which satisfy in their complete extent all properties of non-Euclidean planes. These three geometries each correctly describe a different imaginary space but none of the three exactly describes the actual space that exists to our senses.

The point in discussing these differing geometries at this part of the geometry course is to re-emphasize the proposition that all so-called "truths" are only relative truths; that their validity depends entirely on the basic assumptions which underlie them.

Hence, not only in geometry, but in all matters, an intelligent person will always investigate the assumptions on which an argument is based before giving assent to the conclusions reached.

For example, consider the President's statements about selling military aircraft to France. On what assumptions were his conclusions based? If we were to agree that our interests were identical with those of France and England, would not his position be the logical one to take? What effect on the validity of this conclusion would a denial of our community of interest with France and England have?

Again, a motor car company advertises, "Only our car has

<sup>7</sup> Roberto Bonola, *Non-Euclidean Geometry*, p. 146.

these features." A competing company advertises another long list of features in which its car excels, most of which are not mentioned by the first company. What assumptions do these advertisers expect you to make? If you accept the assumptions of the one company, what conclusions naturally follow? Both are advocating solutions to the same problem, namely, what is the best car for a given person? Is either solution exclusively and exactly correct?

Are there any similarities in the situation mentioned above and the questions concerning the different types of geometries? Would you expect to find that in each case the validity of the argument depends on the assumptions basic to it?

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#### CHANGE IN NAME OF "THE AMERICAN PHYSICS TEACHER"

*American Journal of Physics* is the new name of the bi-monthly journal formerly known as "The American Physics Teacher," as the result of a recent action taken by the executive committee of the American Association of Physics Teachers concerning its official journal. The journal, which remains under the editorship of Professor Duane Roller, of Hunter College, will continue its policy of stressing the educational and cultural aspects of physics, and the instruction of college and university students who are specializing in physical science and of students who take physics as part of a liberal education.

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#### MAN WILL THINK HIMSELF OUT OF PRESENT TROUBLES

I don't believe for one minute that everything we have gained in thousands of years of experience can be wiped out in one disaster. Man has used his ability to think to create the present situation. He has not lost this accomplishment and will, as a matter of course, think himself out.

We are living in a changing world. Right now we are suffering because somewhere in the past changes were not made when they occurred. We have had setbacks in progress in the past and come up stronger than ever. The fundamental forces which bring positive changes are still at work. They will overcome all temporary obstacles in the end.

CHARLES F. KETTERING

## SOCIALIZED SCIENCE PROJECTS

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Some science teachers have used various types of student projects; however, teaching by this means is still quite largely in the experimental stage. This type of work is generally undertaken with the idea of making the science course more functional—that is, to make the material more suited to the needs, interests, and abilities of the learner, and to teach in such a way that the learning experiences are more meaningful. Many points of similarity will be found between the method described here and those used by others. Some things are different, particularly in regard to a greater degree of socialization, the use of a correlated group of topics, and methods of grading.

In life out of school we must carry on two types of activities: those we do alone and those we do in cooperation with others. If school is to better prepare one for life situations, experiences in these two areas should be brought into the classroom to a greater extent. Although we have our extracurricular activities for training in social relationships, we are beginning to think that this type of social training should have its place in all school situations and not in just one restricted area. In passing, it might be pointed out that if we examine many of the newer teaching methods (which supposedly fit in with modern concepts of education in a democracy) they are found to be really directed toward an emphasis on the individual. Some of the things being practiced are: the use of individual projects, individual guidance, individual study and testing programs, the use of workbooks, no discussion, etc. These activities do not lead to skill in social relations.

Projects are one of the newer educational tools, but most of the experimenting has been done on the grade and junior high levels, with relatively few attempts using senior high groups. We science teachers working with this more mature group of students must do a greater share of this experimenting and exchange ideas more freely to see whether better methods and techniques can be developed so that projects may make a more definite contribution to secondary science education. It is with this idea in mind that the socialized science project organization is being submitted, even though we should not be satisfied with the way it works in all respects. The method is an attempt

to make our school life more democratic and to take greater account of social groups in planning the educational experiences of the students in a high school chemistry class.

When using something new in our classrooms we should have in mind certain things that we wish to accomplish by the experiment. All too often experiments in the classroom are undertaken with nothing in mind except just "to do it differently"—a poor state of affairs for *science* teachers. The type of project that is to be described is believed to serve these purposes:

1. *It is functional education.* Projects are selected that are useful to the learner. The projects help make him a more intelligent consumer of goods and services, and help him to better understand some of the vital social, economic, and scientific problems of the age.

2. *Training in cooperative enterprise.* To give the students opportunity to practice in the classroom the type of activity upon which so much of our present day society depends. We recognize that the day has long since passed when the lone workman, inventor, scientist, or business man is likely to accomplish a great deal by himself. We find, instead, that cooperative effort is the method of the age.

3. *Training in methods of investigation and interpretation.* The students learn where to find things, how to find things, and to critically interpret the findings. This is research done on the secondary school level.

4. *Training in presenting and discussing topics.* Students practice presenting project investigations in a clear, factual, and unbiased manner. They experience discussing the topic in a science group. Where would be a better place than under the guidance of a science teacher to get training in this? Isn't this more to be desired than the type of emotionalized argumentation that often enters into a debate? In some schools little or no discussion or other oral work is done by the students, and in time it will lead to but one thing—a demand that the speech department come forward with another required course to correct the deficiencies of the students in speaking before a group and taking part in discussion.

5. *It provides interesting and worthwhile variety.* Even the best methods are not of equal interest for the whole year. Occasionally we all like to do things differently. It's good for us. This method lends a freshness to the course that has a definite educational value.

## THE STEPS IN ORGANIZING SOCIALIZED PROJECTS

1. Preliminary discussion
2. Selection of project work groups
3. Organization—election of chairman, etc.
4. Preliminary reading
5. Tentative outline of the work
6. Conference
7. Library work—locating references, reading, note taking
8. Outlining project—setting up problems, experimental procedure, assigning work among members of the group, etc.
9. Conference
10. Work on the unit—further reference work, laboratory work, community and home investigations, etc.
11. Summarizing the project—making a brief outline of the topics under investigation
12. Conference
13. Organizing data and preparing reports
14. Evaluation

Some of these steps take several days; some take but a short time. This organization cannot be carried out strictly step by step without variation; however, it has been found to serve as a very satisfactory general guide. It will be noted that this outline is in some respects similar to that used by Mr. Chrisman.<sup>1</sup>

Our projects are all organized around a central topic and together make up a teaching unit covering a division of the course material. In this way we get partially away from the tendency of some students to regard this work as "just projects." The following are some suggested fields in chemistry from which projects may be selected: obtaining and using metals, consumer's goods and problems, fuel and power products, industrial chemistry, and household chemistry. Since the students are not as familiar with the equipment available to work with as need be in setting up the kinds of projects to be undertaken, the teacher will likely need to select the areas in which projects are to be selected.

A few days before beginning the projects some time is used in a class period to announce the work to be undertaken. The projects are outlined briefly, the method of carrying out the

<sup>1</sup> Chrisman, E. B. *Two Years With Chemistry Projects*, SCHOOL SCIENCE AND MATHEMATICS, XXXIX, pp. 162-164, February, 1939.

work is explained, and attention is called to the fact that this is to be a project that will largely depend upon group cooperation for its success. The students are asked to think about the projects and decide which they prefer. A few days later they indicate their preference, and the work groups are formed. The students' choices are accepted in as far as possible, but sometimes the teacher must assist in forming the groups in order to keep some from being overfilled or to keep decidedly incompatible students from being put together in the same group. We have found that to keep the greatest interest not over six projects should be used at any one time, and it is best to have not less than three or more than six students work together in the same group. We have occasionally found it desirable to have two groups working on the same type of project in the same class.

The time spent on projects depends upon the length of the class period, what one wishes to accomplish, the equipment, the reference material, etc. Sometimes I feel that too much time is spent on projects, and, as a result, the students tend to let down, waste time, and the work loses its effectiveness. In our case, twelve to fifteen days (including those spent on project reports) have been found sufficient time. These projects are carried out nicely with moderate sized classes. The work is most successful where there is movable classroom equipment and where a rather loose laboratory organization can be allowed for a time. The students are ordinarily quite interested in these projects and will do some of their best work on them.

After the groups have been formed the students in each gather around a table or push their chairs in a circle and start their work. As soon as a chairman and a secretary have been elected, the members of the group begin reading to find out more about their project. The students are fairly well prepared to start outlining significant problems and activities after spending a while doing this preliminary reading. This work should not be undertaken unless considerable reference material is available, and the students should have free access to it whenever it is needed. Wide use can be made of original source material in magazines, government reports, survey books, etc. Careful attention should be given to see that the students learn to interpret accurately the data they find. Some good, free reference material can be obtained, but it is disappointing if one waits until beginning the projects to start collecting it.

The conferences between the project groups and the teacher are very important. During these conferences questions are asked, suggestions made, additional problems pointed out, etc. It sometimes is found that the students have outlined too much or too little work for their project. During the conference, suggestions can be made which will lead to the solution of these difficulties. Although the outline above shows only the three most important of the conferences, the teacher should try to give at least a minute or two to each group each day. The conference is the teachers most important work while the projects are being developed.

This work should be based upon more than experimental investigations in the laboratory. Our project on the destructive distillation of coal will illustrate some of the problems and activities that will make the work truly functional and a well rounded study. In this project the work consists of such things as: setting up the necessary equipment and distilling coal for primary fractions, studying the combustion products of coke and gas, uses for the various products, yields of the various products, value of the products, commercial methods used, a short history of coal distillation, the possible future, and the principal social and economic factors concerned. The work is carried out in the laboratory, in the library, and around the conference table. In addition, it frequently calls for excursions, interviews, and home and community investigations.

The students organize and carry out their work under the guidance of the teacher. It is not required that the work be organized any set way, and it is not required that the work consist of certain set activities. The results are quite satisfactory. The taking of responsibility by the group and the resulting accomplishment far outweigh the occasional cases where the method leads to mediocrity. Each student's responsibility does not end with his own assigned duties; he is expected to be familiar with the whole project.

Since the projects cover a correlated body of subject matter, the whole class can be taught the more significant and interesting things brought out in the study by the oral reports and the resulting questions and discussion. Of course, one period spent on a project topic will not enable one to penetrate very deeply into the subject. Factual subject matter can probably be taught better by taking more time as we do when using traditional teaching methods. However, the students gain a knowledge of

the more essential principles from the reports, a rather extensive knowledge of a project of their own choice, practice in organizing cooperative projects, and experience in investigating problems. This, I think, far outweighs the neglect of some factual knowledge for a few days.

Each group prepares an outline covering the most important points to be given in their report. The outlines are given to each student in the class before the report is presented. The students look over these to get an idea about what they are to hear, and they save them for review. The students are more likely to ask questions about those things not understood if they see from the outline what is important and what is not. The outlines also serve the group as a guide in preparing their report and as a help to the teacher in making the final check during the last conference to see just what has been done, what has been found out, and whether additional investigation should be suggested. It is a good idea for the students to take notes on the reports; thus they keep more alert and get more out of them.

Each group is given one period for their oral report. The students are encouraged to organize these so that they produce the best of which their group is capable. Sometimes each of the members give a section of the report; sometimes it is decided to have it given by only one or two of the members. Demonstrations, the showing of products and charts add to the interest of the reports. Following the reports, the chairman or one of the other members of the group leads a discussion during which questions are asked, and other points of interest are considered. Time left at the end of the period may be profitably used by the teacher for pointing out additional things that have come to his attention during the period. If the interest is high and some of the points have not been adequately treated, the discussion can go over until the next meeting of the class.

Only one written report is asked from each group. Each of the members generally prepare a section and turn it over to the chairman or secretary to arrange and type. But just how this is done is left to group planning. The report is expected to cover the work done on the project in a quite thorough manner.

The evaluation of this work consists of three parts: evaluation of pupil accomplishment, pupil evaluation, and teacher evaluation. However, the methods for doing this are inadequately developed as yet. The following records, kept on a

special record sheet, have been used for determining the grade for each individual:

1. *Group progress.* Each day a grade is recorded showing the group progress. This grade is based upon how much has been done, how well the members work together, and whether good use has been made of their time. If a simple grading scale is used and a few minutes set aside near the end of the period for this grading, it will not be found a very difficult task.

2. *Individual accomplishment.* The keeping of this grade is found to be more difficult than the above grade. It is based upon what the individual does.

3. *Oral report grade.* Each member of the group assists in planning and carrying out the project; therefore he is made to feel a responsibility for the success of each part regardless of whether he worked on that particular job or not. The whole group gets the same grade, based upon the material in the report and how well it is presented.

4. *Written report grade.* This is also given to each person in the group submitting the report.

5. *Test grade.* A test over the work is given after all the reports have been heard. It consists of one part of such a nature that it applies only to the project the student himself worked on and another part over all the reports.

The test is not over emphasized, the project grade depends only in part upon it, since in this work things other than factual knowledge—cooperation, methods of solving problems, organizing group activities, etc.—are given primary consideration. However, the test may be so constructed that these other things may be tested for. The test encourages a better study of the materials in the reports; thus the most important generalizations and facts are learned by all the students.

The pupil's evaluation consists of filling out and returning unsigned a small blank on which is indicated what is liked or disliked about the work, how well the group cooperated, whether or not the materials were adequate, whether or not the work was worthwhile, suggestions for improvement, etc. From these answers I have gotten some ideas leading to improvement of the project work.

The evaluation by the teacher consists of trying to decide whether or not the method accomplishes the purposes of good education. The teacher must ask and try to answer questions such as the following: Is the purpose outlined educationally

sound? Are the students growing along the lines indicated by the purpose? Are there things of doubtful value? Should some things be done differently? Was the right amount of time spent on the work? Etc.? The grades kept, the pupils' evaluation blanks, and observations made as the work progressed are used in making this evaluation. Published evaluatory instruments, which consist of a list of points to be observed and scored, may be found helpful in this work.

Taken as a whole, I regard these projects as being worthwhile. I do not believe they should be overworked, but if used once or twice during the second semester, they have definite value. These projects should not be used exclusively as a method of instruction; all topics do not lend themselves to this type of teaching. A very large majority of my students have indicated they were in favor of these socialized projects; but, of course, a few did not care for them. The general class spirit has always been very stimulating while this work was being done.

Even when students of various abilities are placed in the same group, these projects are found to work nicely. The poor student receives somewhat the same feeling of accomplishment as he does as a member of the school band where, although his own contribution may be of a very ordinary nature, he feels as much pride in the final product as any member of the group. On the other hand, the better student has the opportunity to lead and carry out some of the more difficult and challenging problems concerned in the project. What finer thing could be desired than to have each student feel that his own work has been a worthwhile contribution to a group enterprise.

In their comments as to why they like this work the students mention such things as: it gives one a chance to learn cooperation, it makes one feel grown-up to plan the work, it's interesting, the projects are practical, one can accomplish more, it allows for more research, etc. Some few students suggest that the class reports should be better organized. Unfortunately, we have had some reports that were not very good. It is hoped that this may be corrected by a greater use of the outline sheets, more careful checking to see whether the students are ready to report, and greater training in how to make oral reports.

Some students that are unwilling to cooperate do not care for this project work. A few students object to having any part of their grade depend on what others of their group do. It is pointed out that in any social group we have people of all types

and abilities, and the way we live and what we do depends to a large extent upon others. We need to learn how to work with them. In carrying out these projects the groups experience various degrees of success and failure. The teacher can show the students the importance of each member of the social group performing his duties to the best of his ability. He may lead the students to a better understanding and appreciation of our life in a cooperative democratic society. It is constantly kept before the students that they should plan and carry out the work in a spirit of fair play and cooperation in order that the group produce its best. The teacher misses an opportunity if he stops after teaching just the chemistry that is involved.

These projects cannot be regarded by the teacher as a time to rest. Instead, they are found to be one of the hardest jobs of the year, but this is a type of thing that may find a more definite place in modern secondary science practices. It seems that it may lead to the accomplishment of some desirable things.

### THE QUADRATIC FORMULA

B. LEWIS WAITS

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In the October, 1938 issue of *SCHOOL SCIENCE AND MATHEMATICS*, Mr. Walter I. Murray derived the quadratic formula by using Cardan's method of substitution for the solution of the cubic equation. If the complex number  $X + iY$  is substituted, the method is very much simplified. The writer has used this substitution very successfully with advanced students of second year algebra.

In the general quadratic equation of one unknown

$$ax^2 + bx + c = 0,$$

we put

$$x = x_1 + iy_1$$

and obtain  $ax_1^2 + 2ax_1iy_1 + ai^2y_1^2 + bx_1 + biy_1 + c = 0$ .

In this equation we put for  $i^2$  its value  $-1$  and get the two equations,

$$(1) ax_1^2 - ay_1^2 + bx_1 + c = 0$$

$$(2) 2ax_1iy_1 + biy_1 = 0,$$

which must equal zero separately, since the derived equation from which they are obtained is a complex number and itself equal to zero.

From (1)  $y_1^2 = ax_1^2 + bx_1 + c/a,$

From (2)  $x_1 = -b/2a.$

From the last two equations, by substitution follow,

$$y_1^2 = \frac{-b^2 + 4ac}{4a^2} \text{ or } y_1 = \frac{\pm \sqrt{-b^2 + 4ac}}{2a}.$$

Now putting for  $x_1 + iy_1$  its value  $x$ , we get,

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

## A COMPARISON OF THE RESULTS OF SCIENCE EDUCATION—1859 AND 1939

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In the year 1859, a sixteen-year old student at Mt. Holyoke College, Massachusetts, wrote a composition entitled "The Starry Heavens." As you read it below, you will notice its polysyllabled words, flowery phrases, and involved sentences. What would be your estimate of this student's knowledge of her subject? What understanding of scientific principles seems to be evident?

### THE STARRY HEAVENS

CELIA A. SYKES

The starry heavens present, even to the uncultivated observer, a sublime and elevating scene. We behold the earth, surrounded in every direction by an immense concave hemisphere, which rests upon the circle of the horizon. We may go abroad on the surface of the earth, or on the broad ocean and this beautiful vault still seems to encompass the world. Numerous lights are displayed in every part of this lofty arch which keep moving on in silence inspiring us with awe and admiration. The rude savage is at once attracted, and is struck with admiration at the view of the starry heavens, and he regards them as the residences of their gods, or the judges of their future destinies. But to minds that are enlightened and cultivated the firmament presents a different scene, far more magnificent and beautiful. Its concave rises toward immensity and stretches on every hand to regions immeasurable by any human intelligence. It opens to our view a glimpse of orbs, of which their grandeur and magnitude cannot be conceived; and their numbers are so arranged that they cannot be counted. They have shone upon the earth during hundreds of generations.

These innumerable globes of light are created for use. They were not launched through the space of infinity at random merely to display the energies of Omnipotence, nor were they made for useless splendors. Such a supposition does not agree with the honour, reputation and character of the All Wise Creator. These immense bodies must be conceived as intended chiefly to diffuse light and splendour to surrounding worlds, and the means of communicating happiness to the different orders of beings, with which they may be replenished. As we derive advantages of these orbs, distant as they are, and as they form the lighting of our earthly habitations, so they will likewise adorn the firmaments of other systems; and they display to the inhabitants the manifold wisdoms of God. These lights are intended to fulfill a higher and nobler purpose than to give light to the globe on which we live. This purpose has reference to the happiness of the intelligent existence either in the stars themselves or in worlds which revolve about them. But to suppose this innumerable host of stars to be globes hung up for the purpose of giving light to the void space of infinity would be contrary to the knowledges and revelations of the Being of infinite perfection. If the fixed stars furnish light and influence to surrounding worlds how numerous that empire must be over which the Almighty reigns. Amidst the silence of the midnight scene they impress the soul with solemn awe and reverential emotions. They excite wonder,

astonishment, and admiration in every mind and have a tendency to raise our affections to Him who is the Creator and Governour of all things.

That yellowed manuscript was found recently in a New England attic, and was sent to me, her granddaughter, because of my interest in science education. There straightway came to me as I read it, this question: Just what have the years since 1859 accomplished in the thinking of our students of fifteen and sixteen, our secondary-school pupils? What sort of a composition would a girl of today write under the same title?

To answer these questions, I chose a class in General Biology, all members of which had had Junior High School Science, and without explanation, asked them to write a few hundred words on "The Starry Heavens." After the papers were in, I explained the situation and read the 1859 composition to them. As you can guess, the class "got a great kick out of it." Comments ranged from "My, she must have been bright!" to "Do you think she knew what all those words meant?" I have chosen one of the 1939 efforts to quote here—it is neither the best nor the worst in the group—but simply what seems to me to be the typical example of the thinking of a fifteen-year old student of today.

#### THE STARRY HEAVENS

When you are out in the country on a silent winter or summer night and look into the heavens, you can see about three thousand stars and many constellations. In July or August, looking overhead, you could probably see the Milky Way stretching far out across the sky and wonder how such a realistic thing could contain such a tremendous number of stars. You could see the constellation Lyra, the Lyre, with the brilliant star Vega shining in it. You could see Scorpio, the Scorpion. In early June, Leo the Lion is one of the best to see, with Regulus in its lower corner. Looking South, you can see the war god planet, Mars, shining with the brilliance of a first magnitude star and wonder how many scientists are at present thinking and turning their telescopes toward it to find out whether or not there is any kind of life on it. In July and August this year, it was 36,000,000 miles away from the earth, the closest it will be until 1950.

—(more in this same vein)—

I think astronomy is the most interesting hobby and study because there is always something to look at whether you have equipment or not. When you see a beautiful falling star (meteor) or see a comet, you wonder what is going on up in the world above you, and hope that you will see the time when there will be rocket ships to explore the universe. Or if rocket ships will not do, there may be telescopes cheap enough for every person who wants to study astronomy to buy one so that they can see the heavens and not have to just wonder what is out in the Starry Heavens.

Outstanding characteristics of this effort seem to be—simple language, knowledge of the practical (to the layman) side of star study, genuine interest and appreciation, thought for the

future. Now what is there in this comparison which is of value to science educators? What progress, if any, have we made in the field of secondary school science? Have the hundreds of articles, research studies, and books on the subject resulted in an increased excellence in science teaching and a corresponding increase in the benefits of science for our students? Does the 1939 version of "The Starry Heavens" (taking the two compositions as springboards into the question) show the results of a worthwhile experience in science, both in and out of school?

We all realize that the objectives of science teaching in our schools have changed considerably in the past eighty years. The schools in 1859 had but recently incorporated the study of science in their curricula and their objectives were both practical and idealistic. Today, such objectives as "skill in scientific thinking," "scientific attitude toward life problems," "accurate and useful knowledge of scientific facts and laws," and "leisure time interest in science" find their way into our educational literature. There seems to me to be no doubting of the practicality of these objectives in this day of scientific achievement. Our only problem is the achieving of such perfection in our program of sciences in the schools that the objectives will be realized to the highest possible extent.

I cannot, of course, give the answer to our question. Research studies analyzing the extent to which our science courses are functioning in the out-of-school lives of our pupils can give the answer for the present. The ultimate answer must come some ten years from now in the scientific attitudes, scientific habits of thinking, knowledge of and interest in science, which will or will not be found in the pupils who are today experiencing our science program.

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#### MATHEMATICS TEACHERS MEETING

The National Council of Teachers of Mathematics will have its 20th annual meeting in St. Louis, February 22-23, 1940. The theme of the meetings will be "Mathematics for the Other-Than-College-Preparatory Student." All phases of this theme will be discussed in the four divisions of the meetings: I General Meetings, II Elementary Schools Program, III Secondary Schools Program, and IV Teacher Education Program.

Details of headquarters, banquet, speakers, topics, and places of meeting will appear in the January and February issues of *The Mathematics Teacher*. Questions and suggestions should be directed to 525 West 120th Street, New York City.

## FORMULAS IN PHYSICS

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During the past several years it has become the custom to present physics to secondary school students as a highly rationalistic study. The use of textbooks and problems has steadily encroached upon the place of the laboratory and direct observation until considerable evidence is being marshalled to show the validity of total removal of such materials from first-hand student contact.

The standard instructional technique seems to be the presentation of a law or formula, together with demonstration, then the use of laboratory, if any, followed by the assignment of problems. Nowhere does the pupil touch actual life experience, though adjustment to this need is found in textbooks in the listing and cursory description of applications. The teacher, beleaguered by poor learning of the laws, never has time to talk in detail of applications; he usually must leave that to the pupil's outside reading.

The heart of this instructional technique is the law, in many cases expressed even in elementary courses as an algebraic equation. It is an incomplete realization of the functions and nature of such laws that causes pupil and teacher to experience difficulty with their presentation.

As an example of the nature of physical laws and their algebraic expression, consider the well known development of the laws of uniformly accelerated motion.

Galileo's first step, say the historians, was the postulation of the uniformity of motion under gravitational forces; then he set about proving the validity of his postulate by the actual speeds, measured in terms of distance traversed along an inclined plane. At this level, the rationalistic teaching approach would be correct, for this is certainly a rationalistic technique, checked by experiment. If a teaching procedure is built from this example, however, one fact is overlooked—the fact that Galileo saw a problem; he already had had experience which called for explanation. His postulation and experimentation followed the problem in which physics teachers primarily are interested. If it were possible to get physics students to feel the need of postulates, half the teacher's battle would be won.

Galileo was much disturbed by his experience. Everything

around him called for explanation; his famous "scientific method" was established as he attempted to make the explanations. It should be noted, however, that the method followed his need for a method, and before that was the experience which created the need. Galileo's abstractions were drawn to correlate his experience; immediately thereafter the correlations were checked by more experience.

Now, examine physics classroom procedure. The law is presented, and is bolstered by a demonstration or two—pupil in his place, teacher behind the desk—and after discussion, problems are begun. The pupil probably never has heard of the principle under discussion; his total contact with it now is only a few hours at most, and his experience with it is limited to that given through the medium of purified laboratory apparatus, possibly seen only on the lecture desk. Now, from the pupil's point of view, examine the problem assignment.

We have asked the pupil to use a law he never had heard of to correlate experience which he has not had. Is it any wonder that he balks? Even the genius of Galileo required detailed, multitudinous observation for its mental furniture; he had to have something to correlate!

The situation has been somewhat overdrawn in order that its implication may be clear, that formulas have no validity separate from those experiential data whose relations they express. To teach a formula without a sound, extensive experiential base is to invite mere parroting of instruction. The pupil cannot understand; he has nothing which requires understanding and nothing with which to understand. Formulas are not problem-solving devices in terms of problem lists; they are correlations of the experiences of human beings.

The extensive use of problems cannot overcome the difficulty; if anything, such a technique will increase its magnitude. Assuming that the student has followed the usual route and verbalized the formula, he now is asked to use his unassimilated verbalization to untangle the conditions of a purely intellectual device. The conditions of the device are probably unintelligible to him; he has not seen diving bells or been inside caissons or noticed that a boat sinks lower when someone boards it—it never occurred to him to be attentive to these things! His memory is not sufficiently well equipped to make problems meaningful. In this fact alone may lie a large part of the cause of the automatically selective quality of the physics course;

only the more active intellects, those which from infancy have been highly observant, can succeed in the work. The average pupil does not have the information on which to operate, and the course does not remedy the deficiency.

Lack of experience is not the only factor which vitiates problems as a cure-all for physics instruction, for in addition to difficult visualization, most physics problems use algebra and somewhat complex arithmetic, and a single problem may apply two or more principles. The pupil's mathematical training has been somewhat sketchy in most cases, so that in such a problem he loses sight of his physics in a joust with mathematics—even if his physics is correct he is quite likely to miss a physics problem. Since he has not thoroughly assimilated any principle, the need to apply two principles probably creates a situation at least four times as complex as does a problem which applies only one principle.

Control of tool subjects varies widely with pupils and with schools, but the psychological problems remain essentially the same. Failure in mathematics may be blamed on the mathematics department, if not referred to it, but failure to make due adjustment to the psychological equipment of the pupil rests squarely on the shoulders of the physics teacher.

Intelligent adjustment to the pupil's experience means, first, knowledge of his experience. Such knowledge may be acquired through the use of teacher-built pre-tests for each topic or unit, or through the teacher's study of the pupil's surroundings. In the latter case, it is highly important that the teacher guard against reading too much into the pupil's comprehension. After location and delimitation of the pupil's experiential base for the materials in hand, it is necessary to expand the base to create a need for the material to be taught and to give the pupil concepts by which he may understand that which he is to learn. If these procedures are carried on with a view of the result to be achieved through them, the principle finally may be presented in its correct light, that of a correlation between parts of the learner's experience.

Materials for broadening purposes may be selected from the laboratory apparatus, but for best results, such material should come from the actual environment of the learner, for laboratory apparatus is rarely seen outside the classroom. It may be handled through field trips and pictures for large objects; actual transportation into the classroom for small objects. It should

be borne in mind that the intent is to broaden the pupil's experiential base; "telling" should be kept to a minimum and pupil experience should be the aim. Through experiential growth it is possible to achieve that most important stimulant to learning—a need on the part of the pupil for the information which he is to be taught.

Unfortunately, there is no hard and fast rule to be applied in the extension of the learner's base; teaching experience is the only guide. But, as Morrison suggests by his idea of "rapport testing," it is possible for a sensitive teacher to estimate the extent of the individual and group readiness for presentation of the law. It is sheer waste to attempt the presentation of a principle before pupils see need for it or have the concepts necessary for its comprehension.

Without such techniques, for most learners the laws of physics will remain senseless verbalizations, far removed from existence, and the physics course will merit the oft-heard criticism, "It is too abstract."

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## KNOW OUR WORLD

MONICA KUSCH

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Problems of world-wide interest confront us daily in the newspapers, in magazines and in radio talks. Great emphasis is being placed upon the study of such current problems in the classroom. Many modern curriculums also stress the value of the ability to gain reliable information for one's self in considering some of the important elements involved in such problems. In connection with practically every world problem there is some valuable information which may be gained from the world map. It seems timely, then, to consider the use which is being made in the secondary schools of world maps which are valuable sources of information needed in studying current problems.

Need for a thoroughgoing investigation of the degree to which high school children are learning to use a world map effectively in becoming more familiar with the world in which they live was suggested by the observation of a college class in which the problem of Germany's interest in Rumania was being discussed. The suggestion was made by the instructor that, as an aid to thinking about what there is in Rumania to attract Ger-

man attention, they compare the country with the part of the United States which lies in about the same latitude and is as far west of the Atlantic as Rumania is east of it. In order to find what part of the United States that would be, a physical-political map of the world was examined. Fortunately for the purpose in question, the map was an "equal area" projection and one on which parallels were straight horizontal lines easy for the eye to follow. There were exclamations of apparent surprise or doubt when it was pointed out that if Rumania were moved due westward across the Atlantic and on westward till it was as far inland from that ocean as it is now, it would be superimposed on the state of Minnesota and would overlap it somewhat to the west. The whole attitude was that of, "It doesn't seem possible that Rumania is that far north." The latitude of Bucharest, Rumania's chief city, was found to differ less than half a degree from the latitude of St. Paul-Minneapolis, the chief urban concentration of Minnesota. It was discovered that both were approximately half way between the north pole and the equator. The great surprise expressed at these facts and the questions prompted by them occasioned a digression from the theme under discussion, and the group spent the remaining fifteen minutes of the class period in revising some of their impressions or ideas of the place of the United States and Europe in the world pattern. Facts that especially surprised them were the following:

1. That if you travelled due east from New Orleans you would not touch Europe at any point, but would touch instead the northern coast of Africa.

2. That all of Europe lies north of a line which would continue due east from southern Tennessee and that, with the exception of the Iberian, Italian and Greek peninsulas, Europe lies north of a line drawn due east from the southern tip of Lake Michigan.

3. That there is less than one-tenth of a degree difference in the latitude of Chicago and Rome.

4. That all of that powerful nation, the United Kingdom, is farther north than any part of the United States and that if it were moved westward to North America it would lie between Winnipeg on the south and the northern boundary of Manitoba on the north.

5. That the highly industrialized northern lowland plain of Germany is in the same latitude as in the land near James Bay.

6. That all of the continent of Europe is only about one and a third times as large as the United States, a single country.

7. That the area of the British Isles is approximately the same as that of the state of Nevada.

8. That the well-known and highly advertised Alps Mountains are, in terms of height and extent, much less prominent in the world topographic pattern than are the western mountains of North America.

9. That many well-known rivers of Europe cannot be clearly shown on the world map, for their length dwindles to insignificance in comparison with the lengths of the major rivers of the world river pattern.

After this very intriguing discussion the class planned to search the world map, at some later date, for similar facts about the other continents and their places in the world continent pattern.

It developed further in the course of this animated discussion that these intelligent high school graduates did not know how to discover readily from the map answers to some of the questions which they raised. They did not know, for example, how to estimate the length of Rumania quickly in terms of latitude without referring to the scale of miles. Nor could they tell from differences in their longitudes approximately how far it is from Minneapolis-St. Paul to Bucharest along an east-west line. They erroneously believed that the due east-west line would be the shortest air distance between the two cities. In spite of the fact that they had already discovered that Minnesota and Rumania were in approximately the same latitude, they did not realize that, on any given date, days were of equal length in these two places, nor that the sun, on any given day, was equally far from the zenith at noon. Though the point was not raised in the discussion, an observer could be reasonably sure, since even the reading of simple facts from the map seemed to them new and intriguing, that ideas of distortions of different kinds in various projections and means of correcting them were utterly foreign to their thinking.

A careful analysis of ideas which high school students have concerning the world as a whole probably would reveal many misconceptions which could be easily corrected. Do *your* high school pupils have such a clear general impression of the world as a whole that they could correctly answer without looking at a globe or world map such significant questions as the following?

1. Does any part of South America lie due south of New York, If so, what part?

2. What parts of Europe, if any, lie due east from your home state?

3. What three great rivers of the world have mouths near the thirtieth parallel north?

4. What area of Asia is about how many times that of North America? Of Europe?

5. What country or countries would be crossed in a journey round the world along the fiftieth parallel south? Along the fiftieth parallel north?

6. To what ocean do most of the world's more important lowlands drain? Which is much the largest of the oceans?

Can your students read direction correctly from a map on which parallels and meridians are curved lines? Can they use parallels and meridians correctly in estimating distances? Can they read latitude and longitude correctly? Are they conscious of the fact that sizes are distorted in many maps? Are they in the habit of turning to maps for many valuable types of information or do they shun them because they do not know what interesting facts they show?

A study of the difficulties which many students have in reading maps correctly points to a need for a careful analysis of the world map, its function, and the use made of it in the secondary schools. Without the ability to use maps understandingly, children cannot "know our world."

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### AN INEXPENSIVE IMPACT APPARATUS

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The apparatus consists of a horizontal track made of a 6 foot length of angle-iron on which rest 10 or 12 pool balls. At one end of the track and inclined to the horizontal is another strip of the same stock, the inclination of this last variable as desired. Now if *one* ball is allowed to roll down the incline and impact the system at rest, we find *one* ball leaves the system; if *two* are rolled, *two* leave, and so on. The demonstration shows effectively conservation of momentum and energy.

Although the principles are common knowledge and although many collision apparatus are available on the market this device has the advantage of being very inexpensive. Elastic balls are quite difficult to obtain; steel ones are very expensive. The pool or billiard balls here mentioned can be had for the asking at any pool or billiard parlor. Of course, those gotten are not perfect; they will have a chip or a nick here and there; but they serve splendidly. And they have the very great advantage of being highly elastic.

## THE PLIGHT OF HIGH SCHOOL PHYSICS

### II. Peccant Psychology

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AND

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*" . . . Begin with the line of his (the child's) native interests, and offer him objects that have some immediate connection with these. . . . Next, step by step, connect with these first objects and experiences the later objects and ideas which you wish to instill.*

.....  
An adult man's interests are almost every one of them intensely artificial: they have slowly been built up. . . . The interest now suffusing the whole system took its rise in that little event, so insignificant to us now as to be entirely forgotten. As the bees in swarming cling to one another in layers till the few are reached whose feet grapple the bough from which the swarm depends; so with the objects of our thinking—they hang to each other by associated links, but the *original* source of interest in all of them is the native interest which the earliest one once possessed." (Italics the authors.)

So, many years ago did William James discourse in his "Talks to Teachers on Psychology" (p. 95, 96, 99). Psychology has changed much since James's day but the truth of these words has not been challenged. However it is to no discussion of the whole of psychology in relation to physics, but rather to a consideration of the failure of physics teachers effectively to apply James's more specific rules that the present article is directed.

I take James's words to be in complete agreement with the oft-repeated statement that we are all egoists—the high school student only somewhat less aggressively so than his kindergarten contemporary. Adolescent and infant alike are most actively interested in those things which revolve about that most important of centers, the child himself. This statement is, of course not new but so far as finding any reflection in the practices of physics teachers, text-book writers, and curriculum makers, alike, at least in the main, it might as well be. This curious situation has had, I believe, three effects

1. the continued inclusion of subject-matter which has long since lost its appeal to the bulk of high school students;
2. the exclusion of other interesting material;
3. the failure to organize the teaching material in psychologically interesting patterns.

It is patent, of course that other factors may have had a part in the above, particularly that human inertia that tends to preserve outmoded ways of doing things past their usefulness. It seems equally patent that the rigorous application of the simple psychological principles discussed in the opening paragraph would have improved conditions under all three of the above heads.

Turn to almost any modern text. Chapter 1 in a typical one will deal with measurement. (Why, oh why, must we always begin that way?) Somewhat further on there come a dreary discussion of vector forces probably beginning with a definition of terms, and then going on for eight or more pages to deal with resultants, components, force parallelograms, and all the rest. (Just how close to the interests of a modern adolescent is this sort of material anyway?) This same adolescent *may* be quite interested in the consideration of what constitutes safe speed for his own automobile driving and in the underlying scientific principles but not in the text's tediously academic presentation of accelerated motion and Newton's laws of motion. Similarly he *may* be quite interested in molecular forces either because he is aware of the existence of such forces in his own body, or simply because of the thrill that the very small, the microcosm, seems to have for almost all young people. But how great the interest when molecular forces are revealed as being related to such technicalities as tenacity and elasticity? And so we could go on through the whole book—with the gas laws in the heat section, much of the work on cells in electricity, the laws of strings as they are usually presented in sound, and the lens and mirror formulae in light—but why heap Ossa upon Pelion? The point should be made. Let us therefore turn to the second of my above contentions. Is there material that may be of greater psychological interest to students than that which we physics teachers have traditionally used?

As a case in point let us consider the work in the light section. Our new point-of-view with respect to the immediacy of interest causes us to pay much more attention to vision, to color blindness and to the human eye than we have done, if in no other way, at least as introductory material. The work on lenses may follow from a study of the eye, that in color from considerations of the physiology and psychology as well as the physics of vision, that on illumination from considerations of how the eye behaves in seeing. I cannot forego one quotation.

As regards light, there seem to be two reasons why our eyes are limited to seeing only a single octave of the wave. . . . One is that . . . the greatest amount (of energy) is centered in this region. . . . The other is more subtle and has to do with the properties of light of different wave lengths. Ultra-violet light . . . gets scattered when it passes through the air. . . . Hence a photograph which uses only the ultra-violet rays is blurred and shows no details of the distance. A photograph taken by infrared light, on the other hand, while it shows the distant landscape very well, over-emphasizes the contrast between light and shade in the foreground. Leaves and grass . . . look white, while the shadows are inky-black with no gradations. The result looks like a snowscape. An eye which could only see the ultra-violet octave would see the world as in a fog; and one which could see only the infra-red octave would find it impossible to pick out lurking enemies in the jet-black shadows. The particular range of light to which our eyes are attuned gives the best graded contrast.<sup>1</sup>

The interest which inheres in such writings seem obvious. Furthermore this particular quotation serves as an admirable introduction to invisible radiations and the properties thereof.

Again, in electricity we can profit from the recent discoveries of the electrical character of life. Some findings are almost lurid, as of persons who give off brain waves which vary according to whether they are awake or asleep, thinking or in a reverie, sick or well. George W. Criles' "Phenomena of Life" offers many suggestive leads.

One of the best illustrations of the point-of-view is afforded by the energy unit described in the previous article in this series. It is an experience worth having to note the smiles of satisfaction which enwreath the faces of students as they identify the engine referred to in the following quotation.

In the earliest days the world's first engine operated with surprising efficiency. It was not really one motor but a combination of over three hundred engines, large and small, gathered together under one system of automatic control. None of these had a flywheel, yet each always avoided dead centers. Some of the larger ones contained as many as six hundred small cylinders, joined together in compound. The boiler was capable of burning fuel at a very low temperature. Whereas it now takes ten hours to get up steam on a ship and three or four on a locomotive, this early motor was almost instantly ready for action. It worked at a constant pressure and had an elaborate alarm system to warn the operator when fuel ran low. It was built exclusively on the lever principle and contained about two hundred and thirty bearings all automatically lubricated. As would be expected of so complex a mechanism it got out of order now and then, yet its length of service was surprisingly good. Twenty years is a good life for a modern steam engine but this earliest motor would usually run for more than sixty. And whereas a modern steam engine has an efficiency . . . of only about 15 per cent, a gasoline engine of 20 to 25 per cent, and a Diesel, or crude-oil-burning engine, as high as 35 per cent, this oldest of

<sup>1</sup> Huxley, Julian. "Man as a Relative Being," Part II, Chapter I in Adams, M., *Science in the Changing World*. Century, New York, 1933, pp. 122-23.

all engines would yield an efficiency of 40 per cent. For some five thousand countable years—and no one knows how many uncountable ones—it was entirely without a rival.

This engine was the human body.

The great trouble with the human body as an engine has always been that despite its great ingenuity and high efficiency its total capacity for work is quite small. . . . A Sicilian slaving at a sewer pump eight hours a day can barely develop one tenth of a horse-power.

.....  
In the days of Greece, each freeman owned on the average two slaves. Of Rome, in the days of its greatest glory, Gibbon thought there were as many slaves as freemen. One Caecilius, a freeman in the days of Caesar Augustus, was distinguished by the possession of 4,116 slaves. That seems an opulent number, yet by modern standards they were the equivalent of a mere four hundred horsepower—something less than is now housed every evening under the roof of any public garage. Had Caecilius then had the advantage of knowing Shakespeare he might have paraphrased *As You Like It* and of his best slave said: "An ill favored thing, Sir, but mine only."

The slave left his monuments. He built the Great Wall of China. He built the Pyramids. He built the Roman roads and aqueducts. He was the essence of progress and the measure of wealth in pre-Christian times. But often he must have thought under the sting of an overseer's lash that he might have been better off in simpler days, when cavemen, having no use for conquered enemies, killed them outright. Already, the world's work was an insufferable burden upon the shoulders of men.<sup>2</sup>

Lest I be charged with over-enthusiasm let me hasten to assert that this approach is not the only one to be used. Any method palls when employed without deviation—this one probably least of all.

And finally—how may we organize our materials in psychologically interesting patterns? In the article previously referred to, an outline for the reorganization of the subject, physics, was presented. Let us take one of the units suggested therein and follow it through. The unit is II A—Energy Forms Directly Used by Man—Sound.

We begin with a little theatricalism. The teacher having gained the attention of the class proceeds, with a heavily portentous air to "fuss" with apparatus on the demonstration desk. Suddenly—a loud noise—the blow of a hammer on an anvil, the sudden blare of a loudspeaker, the explosion of a blank cartridge—anything, but sudden, unexpected, loud. As a man the class jumps. Surprise. Emotion of a variety of kinds.

*What effect did it have on you? How do you feel?*

And away we go on a discussion of the effects of noise upon you and me. We read about the findings of psychologists and

<sup>2</sup> Hodgins, E. and Magoun F. A. *Behemoth, The Story of Power*. Doubleday, Doran, Garden City 1932, pp. 1-2, 5-6.

others who have studied the effect of noise upon efficiency and the nervous system. The teacher suggests that the group might wish to undergo a test of their own ability to work under noisy conditions but that it involves experiences which are probably too "tough" for them. No teacher should ask a class to undergo such an ordeal.

*You don't want to try it, do you?*

A chorus of "Yesses"—and the die is cast.<sup>3</sup>

From there we go to the study of how noise is controlled in buildings—the science of acoustics, and to a consideration of what distinguishes a musical sound from noise. (At last we have reached traditional physics!)

Two other leads carry us through the unit. One, concerned with the problem of how we hear, brings in traditional material on resonance, pitch, vibrating strings. The other, concerned with our voice production involves these same three and others pertaining to quality, etc. It may even be that this latter work may help the student to the attainment of a better voice—particularly a speaking voice. Such a result is certainly worthy of the time and effort involved. A more likely result is the sensitizing of the student to what constitutes a good speaking voice, to his own good and bad speaking traits, and possibly to a desire to improve his own speech.

As I glance back over the illustrations cited, I am reminded of another element in the picture. Not only may this approach through the student's own immediate interest—himself—help to give us more interesting subject-matter and a better organization of that subject-matter, but also it should serve partially to meet one of his needs—the need to understand his own body's functioning. This is a task which we physics teachers have long been content to relegate to the biology department. A troublesome thought intrudes! Maybe, after all, an important part of that for which I have been pleading may be summed up under the slogan "Closer integration between biology and physics." At which point I can find no better way in which to bring this rampant steed of discourse to a halt than to use the words which served a similar purpose in the previous article in this series—"If that be treason, make the most of it."

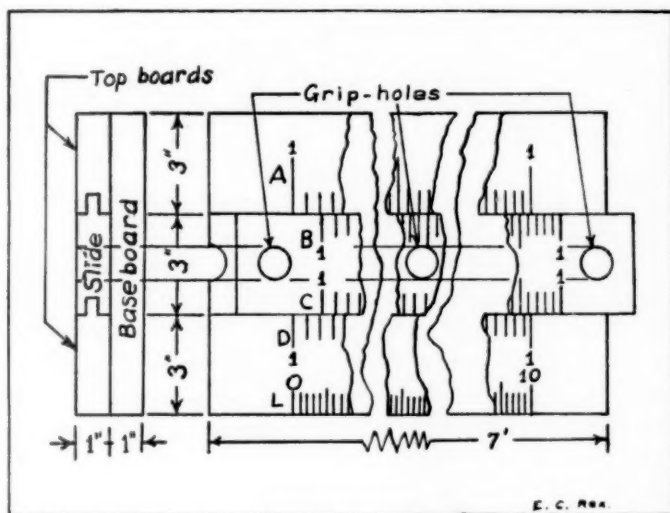
<sup>3</sup> The temptation is great to continue to a description of the experiment and its results but since that has been done elsewhere (See Brown, H. Emmett, "An Experiment to Show the Effects of Noise." *Science Education* 22: 343-48; 1938 (Dec.)) I forbear. Suffice to say the experiment seems to effect a vividly appreciational understanding of the effects of noise upon the individual.

## CONSTRUCTION OF A DEMONSTRATION SLIDE RULE

EARL C. REX

*Grays Harbor Junior College, Aberdeen, Washington*

You can easily make your own demonstration slide rule by employing student labor under the supervision of a mathematics teacher. It can have almost any dimensions, of course, but the best are probably  $7' \times 9" \times 2"$ . With the length of seven feet you may use a two-meter stick which your physics department probably possesses. If not, two one-meter sticks may be used end-to-end.



If the above dimensions are to be used, select a substantial wooden baseboard  $7' \times 9" \times 1"$ . It may be painted white or stained, as desired. The two top boards and the slide may each be a piece of soft flooring  $7' \times 3" \times 1"$ . They should be placed on the baseboard so the groove of one fits around the tongue of the adjacent one, as shown in the drawing. The slide should have three one-inch holes bored partly through it on its face. These holes enable the person who manipulates the rule to place his finger in one of them to move the slide.

When the top boards are in the proper position on the face, nail them in place with finishing nails. Make sure, while doing this, that the slide moves somewhat tightly between the top

boards. Later, the grooves and tongues can be waxed to make the slide move more easily. Counter-sink the finishing nails and fill in the holes with putty. Now paint the top boards and both sides of the slide with white paint. When dry, mark the *A* and *B* scales with pencil. To do this, clamp the two-meter stick next to the board. The left indexes are at the zero of the meter stick. For these scales the readings from a logarithm table should be used. Put the mark for 2 on the scales, for example, at the 30.1 cm. mark ( $\log 2 = .301$ ).

It is best to rule the lines of all the scales in black<sup>1</sup> India ink with a ruling pen set to make a wide mark. The number of lines and their various lengths can conform to any standard type of slide rule.

The two-meter stick can be used again in locating the lines on the *C* and *D* scales. Care must be taken to see that the left indexes of the *C* and *D* scales coincide when those of the *A* and *B* scales coincide. To find the distances of the lines on the *C* and *D* scales from their left indexes, multiply the logs of numbers by two. For example, to find the position of 4, measure .601 by  $2 = 1.202$  meters, or 120.2 cm. from the left index ( $\log 4 = .6010$ ).

The *S* and *T* scales on the back of the slide are located by using the log sin and log tan tables respectively. The left index on the *S* scale represents the angle  $0^{\circ}34'22.7''$  approximately ( $\log \sin 0^{\circ}34'22.7'' = 8.0000 - 10$ ). To obtain the distance from the left index to the mark of any other angle,  $\theta$ , subtract  $8.0000 - 10$  from  $\log \sin \theta$ . For example,  $\log \sin 10^{\circ}$  minus  $8.0000 - 10 = (9.2397 - 10) - (8.0000 - 10) = 1.2397$  meters, or 123.97 cm. The mark for  $10^{\circ}$  is 123.97 cm. from the left index.

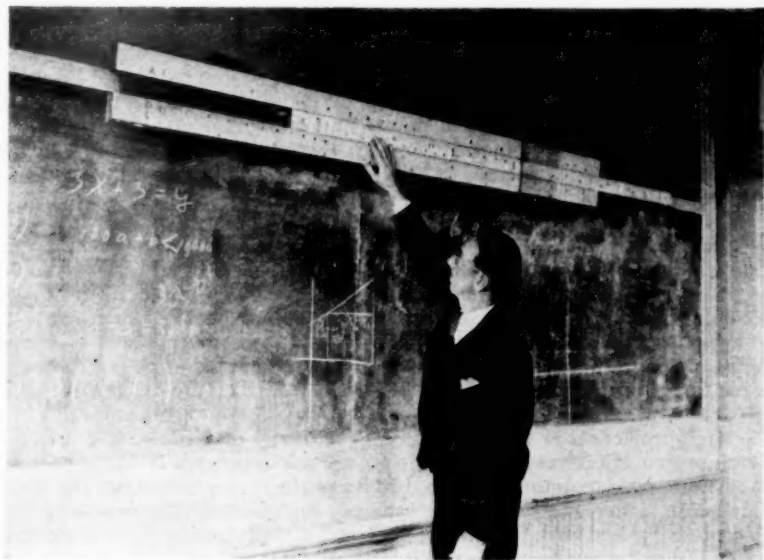
The left index of the *T* scale represents approximately the angle  $5^{\circ}42'21.7''$ , whose  $\log \tan$  is  $9.0000 - 10$ . To obtain the distance from the left index to the mark of any other angle,  $\theta$ , subtract  $9.0000 - 10$  from  $\log \tan \theta$  and multiply this difference by two. For example,  $\log \tan 6^{\circ}$  minus  $9.0000 - 10 = (9.0216 - 10) - (9.0000 - 10) = .0216$ . Multiplying this by 2:  $.0216$  by  $2 = .0432$  meters, or 4.32 cm. Therefore, the mark for  $6^{\circ}$  on the *T* scale is 4.32 cm. from the left index.

If you wish to have a logarithm scale, multiply by twenty each number whose mark is to be located. This gives the distance of the mark from the left index in centimeters. Thus, 2 is 40 cm., and 5 is 100 cm. from the left index.

<sup>1</sup> The *C I* scale should be ruled with red India ink. See below

In case a *C I* scale is desired, rule and letter it in red India ink. This scale is merely the *C* scale inverted.

Mount the slide rule as shown in the photographs, and paint all surfaces with a varnish, hardener, or colorless shellac. This should be done especially over the various scales. Do not brush too vigorously over these, as the ink may smear, even when dry. Fit two one-foot length pieces of flooring to slide, one along the upper and the other along the lower top boards, and bolt the glass runner to these. The vertical "hairline" on it can be a ruled India ink line. It is well to put nails or stops of some kind at the ends of the upper top board to prevent the operator from accidentally knocking the runner off and breaking it.



Cut the notch for the *S* and *T* scale glass and fasten it in with brads and putty. The "hairline" of this glass is also an India ink line.

An estimate of the approximate cost is as follows:

Lumber.....	\$\$.65
Paint, stain, hardener.....	.25
Putty.....	.05
	<hr/>
	\$0.95

Other materials, such as glass, brads, nails, screws, and

bolts, as well as tools such as a hammer, brace and bits, etc., can be found around the workshops or laboratories.

If desired, the glass runner may be made of a 9" by 12" piece of plate glass with a hole bored in each corner. Most hardware stores can furnish this for less than \$2.00.

The demonstration slide rule constructed in the preceding manner at Grays Harbor Junior College has been in constant use for four years. The surfaces have been recently re-varnished. It is in excellent condition, and has been invaluable in teaching the slide rule.

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### A SOLUTION TO THE MICROSCOPE PROBLEM

V. A. REIHMER AND C. G. ERICKSON

*North Park College, Chicago, Illinois*

The problem of getting students to understand histological structure and the relation between tissues of plants and animals is an important one. Teachers of elementary biology, botany, and zoology, and also of some of the advanced biology courses feel the need of a device for showing students exactly what to look for in stained sections.

Actual-color photomicrographs of stained mounts have answered this challenge. Accuracy of detail is limited only by the perfection of the staining technique, and by using the best slides available the authors have made reproductions on 35 mm film which equal the original material in clarity of definition. This clearness of the image is undiminished in the projection. The entire class sees the image of the actual stained section as it would appear under the microscope and very much enlarged. The instructor is able to point out the particular cells or tissues which are being discussed. Teachers will find these slides invaluable for use in practical quizzing.

Microprojection is the most successful device developed thus far for such presentation but difficulties in its use are apparent. Without an able assistant the instructor is required to leave the screen to change the magnification, move the slide, or refocus the microscope. The course of the lecture is broken both for teacher and student and valuable time is wasted. This difficulty can be eliminated by using a projector which anyone can operate. The projector accommodating the photomicrograph slides is very reasonable in price and may be of service to all departments of the school using visual instruction.

This development may, if desired, entirely supplant the individual use of the microscope and remove the difficulties incurred due to the problem of supplying an entire laboratory section with perfect slides of all microscopic material. The real value of the technique, however, is not in providing a substitute for individual microscopy but rather in supplementing it. Its success has been demonstrated in the results obtained here at North Park College.

Most of the work has been done with plant sections but preliminary attempts in animal histology and embryology point to results in those subjects equal to that of botany. The possibilities of development in this field are limited only by the variety of objects observed under the microscope.

## SUGGESTIONS FOR MAKING 2 × 2 INCH LANTERN SLIDES WITH INEXPENSIVE EQUIPMENT

VICTOR E. SCHMIDT

*Cornell University, Ithaca, New York*

Miniature lantern slides are becoming increasingly popular. This is due in large part to their cheapness, ease of storing and handling, and infrequent breakage. Projectors required for their use, moreover, are generally smaller and less expensive than those required to project standard slides.

We have been experimenting with simple and inexpensive devices and methods for making miniature slides by copying drawings, photographs, and illustrations in books and magazines. Without the use of expensive equipment, we have succeeded in producing 2×2" slides at a total cost of less than 5¢ each. These slides may be projected to form clear images which are entirely satisfactory for classroom use. They are valuable teaching aids.

The following equipment and materials are suitable for making miniature slides by the method described below:

A homemade camera and holder. The total cost of these should not be much more than \$1.00. Their construction is described later.

A dark room. If none is available, an ordinary room may be used at night, provided all light can be excluded.

A safelight. A Wratten Safelight, Series O or OA, is satisfactory.  
35 mm positive film.

Eastman D 11 Developer.

Acid fixing powder.

Tumblers or mayonnaise jars.

A commercial or home made printing frame.

Gooseneck desk lamps with 50-watt bulbs.

A 7-watt bulb.

A table.

Running water.

### METHOD OF MAKING SLIDES

The illustration to be copied is placed on the table directly under the camera (see Figure 1). It is sometimes necessary to hold it flat with small weights or a pane of glass. The camera is raised or lowered until the image, as seen on a piece of ground glass or tracing paper placed over the rectangular opening, nearly fills the opening. Focusing is accomplished by turning the threaded lens mount. Two or more gooseneck desk lamps

(not shown in the figure) are adjusted to illuminate the illustration evenly, care being taken to avoid glare into the lens.

Next, a fiber diaphragm is placed in front of the lens. The white lights are switched off, and under the safelight, a short piece of 35 mm positive film is placed, emulsion side down, over the rectangular opening. It is held in place by a weighted piece of wood, or other flat weight, slightly larger than the film. The lamps are then switched on to give the exposure. With four 50-watt lamps placed about 8 inches from the center of the illustration, and 12 inches from the top of the table, exposures of from 20 to 40 seconds give good results.

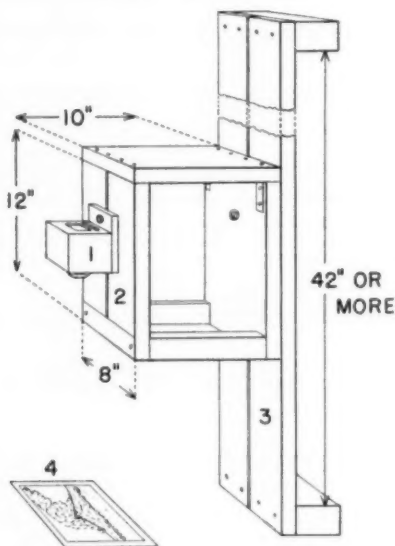


FIG. 1. The camera and mount.  
1. Camera. 2. Camera holder. 3. Backboard. 4. Illustration to be copied (on table).

The exposed film is developed in Eastman D 11 Developer according to directions on the can. The degree of contrast of the negative depends on the concentration of the developer.

After being rinsed, it is fixed in acid hypo for twice the time required to clear the film of all milkiness. It is then washed thoroughly in running water for at least 30 minutes, and hung up to dry. Developing and fixing may be conveniently done in tumblers or mayonnaise jars.

A contact print is then made by placing the negative on

another piece of positive film in the printing frame, and exposing to light. Good results may be obtained by placing the printing frame 3 feet from a 7-watt bulb and giving an exposure of about 5 seconds. The method of developing and fixing the positive is the same as that used for the negative. When dry, this print is mounted with a mask between two cover glasses, and the slide bound with tape. Care must be taken in all these operations not to scratch or otherwise mar the film.

Although the process may seem rather long and involved, it is really simple, and good results may be obtained by inex-

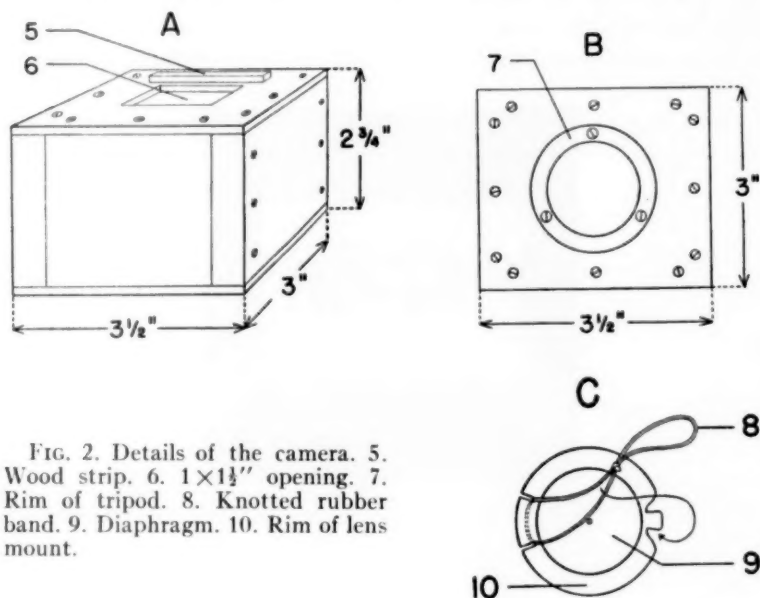


FIG. 2. Details of the camera. 5. Wood strip. 6.  $1 \times 1\frac{1}{2}$ " opening. 7. Rim of tripod. 8. Knotted rubber band. 9. Diaphragm. 10. Rim of lens mount.

perienced pupils. A little ingenious planning may result in "mass production" of good, cheap visual aids.

#### CONSTRUCTION OF THE CAMERA AND HOLDER

The box of the camera is constructed as shown in Figure 2A. The top and bottom are of  $\frac{1}{8}$ " Presdwood, while the sides are of  $\frac{1}{2}$ " pine. A rectangular opening,  $1 \times 1\frac{1}{2}$ ", is cut in the center of the top piece. A circular hole,  $1\frac{7}{8}$ " in diameter, is cut in the center of the bottom piece to receive the lens mount. The parts of the box are screwed together tightly. The joints may be made more light-tight by pasting opaque paper over them

on the inside. A small strip of wood fastened  $\frac{3}{8}$ " from the back edge of the rectangular opening helps in centering the film over the opening.

The lens and lens mount consist of a Bausch and Lomb tripod magnifier from which one of the lens elements and the three legs have been removed. The threaded rim of the tripod fits into the hole in the bottom piece and is held in place by small screws inserted in the three holes, as illustrated in Figure 2B.

The diaphragm consists of a circular piece of thin fiber or cardboard,  $1\frac{1}{4}$ " in diameter, in the center of which is drilled a smooth hole  $\frac{1}{8}$ " in diameter (a  $\frac{1}{2}$ " #20 wire nail may be used to drill this hole). It is held in place by a knotted rubber band. The lens mount is sawed and filed to hold the rubber band as shown

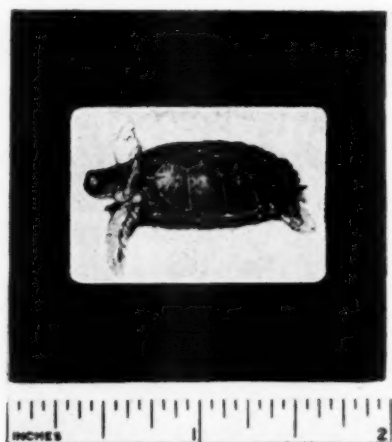


FIG. 3. A finished slide.

in Figure 2C. With the use of the diaphragm, illustrations of about  $2 \times 3$ " to about  $12 \times 18$ " may be copied. To copy smaller or larger diagrams, one must make the height of the camera box more or less than the  $2\frac{3}{4}$ " given in Figure 2A.

The camera may be mounted in several ways. The device shown in Figure 1 is efficient and simple. A piece of  $\frac{1}{2}$ " pine,  $3\frac{1}{2}$ " wide and 4" high, is screwed to the back of the camera so as to be flush with the bottom and sides. A  $\frac{1}{4}$ " stove bolt is inserted through a hole in the upper part of this piece, and fits into the slot of the camera holder. The camera is held securely in place by tightening a wing nut on this bolt in back of the holder.

The camera holder itself may be constructed as shown in Figure 1. Angle irons or small shelf brackets may be used to reinforce and insure right-angle corners. The holder is held firmly against the slotted backboard, which is fastened to the wall, by another  $\frac{1}{4}$ " stove bolt and wing nut. This arrangement permits rough adjustment of the camera by sliding the holder up or down, and more accurate adjustment by moving the camera. This method of mounting may be adapted for a variety of purposes, such as for holding other cameras and homemade enlargers.

The camera and holder described above are easy to construct. They might well be made as projects in the school shop. The designs certainly can be improved, and efforts toward this end should prove stimulating to pupils with inventive bent. Moreover, by constructing and using the camera, a pupil gains a more thorough understanding of underlying principles than is possible by reading alone.

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## HIGH LIGHTS OF THE FEBRUARY SKIES

JAMES L. RUSSELL

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DAVID W. RUSSELL

*National College of Education, Evanston, Illinois*

[Editors' Note: This is the fourth of a series of popular astronomy articles. If these articles are saved from month to month they will make a useful reference book for elementary and secondary school science teachers.]

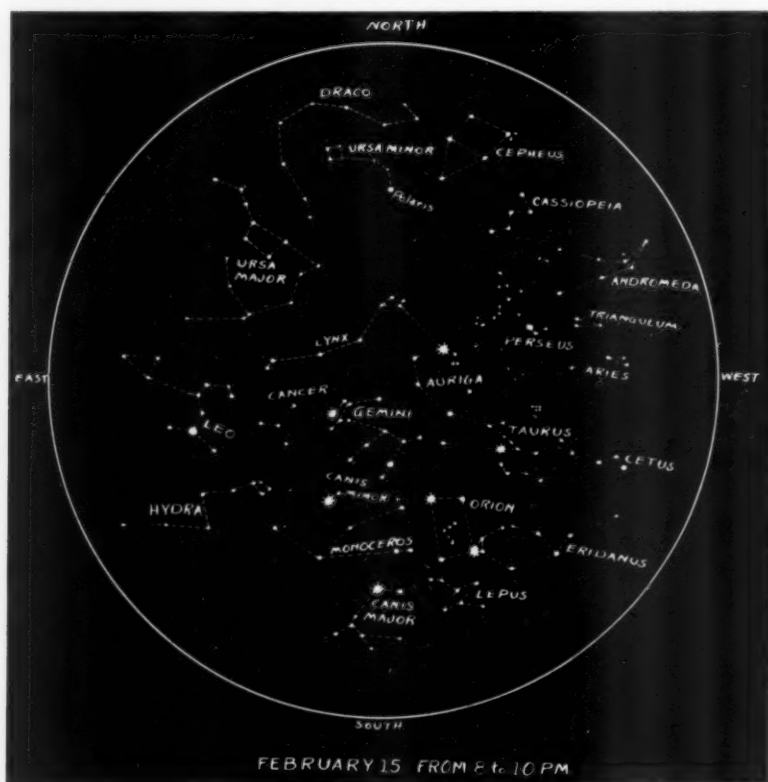
February is an interesting month, for 1940 is leap-year, and "Februarius" has 29 days to make up most of the time we have missed during the past three years. The calendar has been the subject of much speculation since the astronomer Sosigenes made the Julian Calendar during the reign of Julius Caesar. America and most countries use a revision of the Julian Calendar, called the Gregorian Calendar, which gives February 29 days if the number of the year is evenly divisible by four and if the number of a century year is evenly divisible by 400. So 1900 was not a leap-year but but 2,000 will be! The Russians have even a more accurate calendar that agrees with our until about 2,800 A.D. when America will lose a day and the Russians won't. The stars in a leap-year February are about the same as other Februaries.

### I. CONSTELLATIONS AND STARS

Northwest of *Sirius*, *Orion* still dominates the winter sky. The bright star forming the northeastern corner of *Orion* is *Betelgeuse*, and the bright

star in the southwest corner is *Rigel*. The three faint stars in the center form the "Belt of Orion," and are sometimes used as a measuring stick by amateur astronomers, since the belt is just three degrees long! The famous *Great Nebula in Orion* is found just a trifle south of these three stars and can be seen in a pair of opera glasses. To the unaided eye it appears as a fuzzy point of light.

Following *Orion* along the ecliptic to the east is the constellation *Gemini* which is closely followed by the inconspicuous group of stars named *Cancer*. Coming well into view further east is the constellation *Leo*



with the bright star *Regulus* at the end of the group of stars forming the handle of the famous "sickle." These constellations are four of the twelve constellations of the *Zodiac*. Because the earth revolves around the sun, the latter appears to move eastward among the stars about one degree a day. This apparent path of the sun among the stars is called the *ecliptic*.

The belt or zone of the sky, 18 degrees wide and bounded by lines 9 degrees from either side of the ecliptic, is called the *Zodiac*. There are twelve constellations along the ecliptic which are called the *Zodiacal Constellations*. In order, they are *Aries*, *Taurus*, *Gemini*, *Cancer*, *Leo*,

*Virgo, Libra, Scorpius, Sagittarius, Capricornus, Aquarius and Pisces.* The *Zodiac* has been divided into twelve parts, each 30 degrees long, which bear the same names as the zodiacal constellations and in the same order. The starting line lies at the *vernal equinox* and they go eastward. Long ago the signs and constellations having the same names were in about the same positions, but due to the *Precession of the Equinoxes* they have shifted westward. The *Precession of the Equinoxes* is the slow movement of the *Equinoxes* westward. The complete circuit is made in a little over 25,000 years.

## II. PLANETS

Again in February, the four brightest planets will be visible in the western sky shortly after sunset. *Venus* is the planet of the month and will be seen shining brilliantly high in the western sky after sunset. Nearby will be *Mars, Jupiter* and *Saturn*.<sup>1</sup> *Uranus* and *Neptune* are telescopic objects only and change position only slightly from month to month due to their great distance from the sun.

This month will be the last good chance to see the moons of *Jupiter*, for he is sinking from view not to be seen again in the evening sky until next fall. *Jupiter* has eleven moons. Only the four largest are visible to us with small instruments. These would be visible to the unaided eye but for their close proximity to the planet. Three of these four moons are about the size of our satellite and one of them is smaller. They revolve around the planet in a plane which is placed nearly edgewise to the earth, so that they appear to shuttle back and forth from one side of the planet to the other. Three of the satellites are eclipsed by *Jupiter's* shadow every revolution, and sometimes a satellite transits or passes across the face of *Jupiter*, appearing as a bright spot against the planet's disc, and the shadow of the satellite may be seen as a black spot on the planet's surface and is sometimes mistaken for the moonlet.

## III. CLASS ROOM ACTIVITY

The fact that the stars do not appear to travel directly in a straight line from east to west offers an unusual opportunity for the teacher to make use of an ordinary camera to photograph several interesting phenomena of the sky. It can be pointed out first that since the observer is being carried by the earth's rotation from west to east the stars appear to move from east to west.

Mount an ordinary box camera in such a position that the camera will point as nearly as possible toward the *North Star*. After dark open the shutter wide and allow an exposure of several hours. Carefully protect the exposure from street lights or any extraneous light that might fog

<sup>1</sup> For the positions of the planets, moon or sun, on any given date, refer to the American Nautical Almanac for 1940, which can be obtained at most any library or direct from the government printing office. This publication is very useful. It gives predictions of all eclipses of the sun and moon, and a wealth of other valuable information.

the picture. For best results this should be done on a moonless night on the roof of a high building or an apartment house. The result should be a multitude of circular lines or star trails made by the light from the stars as they pursue their course across the sky. It is not at all impossible that a vivid meteor trail will be recorded on your film as it flashes across the field of the lense. It will be noticed that some of the trails left by the stars do not dip below the horizon. These are called *circumpolar* stars and do not set. It also will be noticed that *Polaris* leaves a faint circular trail which indicates that its position is not true north. The true north will be indicated by the imaginary center of this circular trail left by *Polaris*.

The ingenious teacher with a general knowledge of photography can find many activities for recording meteor showers, star and constellation paths and other celestial events.

### A PLANISPHERIC PLANETARIUM FOR THE ASTRONOMY CLUB

WALLACE A. HILTON

*Hickman High School, Columbia, Missouri*

Astronomy Clubs at the high school level are in need of better ways of studying the celestial bodies. Star maps in general do not reveal the movement of the stars and other bodies of the sky. Neither do they point out the place of the horizon at the various times of the day and the year or the movement of the sun and moon among the stars.

In an effort to overcome these problems the Astronomy Club at Hickman High School has a so-called "Planispheric Planetarium." This piece of astronomical apparatus is a home-made device which does show the movement of the stars, the sun, and the moon during every day and hour of the year. This instrument is powered by a small electric motor which turns at 4800 revolutions per minute; however it is geared down so that the time for one revolution of the map, which corresponds to one day of twenty-four hours, is about five minutes. This is made possible by a group of pulleys which are so arranged so as to reduce the speed about 10,000 times.

All of the stars that may be seen throughout the year at Columbia are drawn on the map that is four feet in diameter. Since all of these stars cannot be seen at any one time, the map is placed behind a frame that is so designed to show only that portion that may be seen at any one time. The edge of this frame which represents the horizon is not a true circle but rather more or less elliptical or egg-shaped. This is due to the change from polar coordinates to plane coordinates and is obtained by some simple calculations in spherical trigonometry.

Objects which represent the sun and the moon are placed just in front of the map so that the paths that they take as they apparently travel through the stars may be easily seen, the sun making a revolution with every 365 revolutions of the stars, and the moon making a revolution each twenty-eight days. A mechanical clock is connected so as to give the exact time of the day and a mechanical calendar gives the date of the various months.

This instrument which we have termed a Planispheric Planetarium has helped to increase the interest and knowledge of the members of the Hickman Astronomy Club in the study of the celestial bodies.

# ANNUAL REPORT OF THE CONSERVATION COMMITTEE\*

CENTRAL ASSOCIATION OF SCIENCE AND  
MATHEMATICS TEACHERS, INC.  
NOVEMBER 24, 1939

## A BRIEF SUMMARY OF FEDERAL ACTIVITIES PERTAINING TO CONSERVATION

*Prepared by O. D. FRANK, University High School, Chicago, Illinois*  
*Additional suggestions by HELEN M. STRONG, Soil  
Conservation Service, Washington, D.C.*

Conservation by the national government is carried on through the Department of the Interior by the following ten agencies:

1. *The Bureau of Reclamation* has built 156 dams which make possible the irrigation of 5½ million acres of land.
2. *The Office of Indian Affairs* provides means of conserving land, timber, minerals, and other resources for the Indians.
3. *The Geological Survey* investigates and records the natural resources of the country.
4. *The Bureau of Mines* conducts inquiries which result in the conservation of minerals and the prevention of accidents in mines, quarries, and other mineral industries.
5. *The General Land Office* has charge of over 750 million acres of land that has been set aside for conservation purposes. More than 100 thousand maps have been prepared and distributed to the public.
6. *The Bureau of Fisheries* operates 110 fish hatcheries which produce more than 8 billion fish and fish eggs each year. Millions of stranded fish are rescued from receding waters. Seal herds have been increased from 130 thousand to 2 million animals.
7. *The National Park Service* administers 155 federal park areas.
8. *The Grazing Service* has under its supervision 142 million acres of public grazing lands.
9. *The Bituminous Coal Division* has established measures which result in the prevention of waste which amounts to 150 million tons of bituminous coal per year.
10. *The Petroleum Conservation Division* is designed to assist the various oil-producing States in conserving oil for future generations.

In the preparation of this summary personal visits were made to Grand Coulee, Bonneville, and Boulder Dams, ten national parks, fish hatcheries, Indian reservations, and a number of other national reclamation projects.

Conservation by the national government is carried on through the Department of Agriculture by the following agencies:

1. *The Agricultural Adjustment Administration* regulates crop acreages and planning in a program designed to continuously readjust the supply of agricultural products to the needs of consumers.
2. *The Agricultural Extension Service*, through a great number of bulletins and publications advances conservation along many fronts.
3. *The Bureau of Biological Survey*—the nation's wildlife protection service—studies the usefulness and conservation of wildlife and is active in the enforcement of federal wildlife laws. Wildlife refuges are provided.

\* The first section of this report was published in the January issue.

4. *The Forest Service* through regulatory and replenishment programs points toward continuous national self sufficiency in the area of forest products.
5. *The Soil Conservation Service* experiments, demonstrates, and cooperates with farmers to the end that the remaining two-thirds of the nation's fertile top soil may be productive, and still be retained for continued use. This service operates 175 demonstration areas in as many different watershed districts. Research is conducted on an extensive scale to determine what corrective procedures are best adapted to the great variety of conditions under which soil erosion occurs. Some thirty-five nurseries are operated to develop types of plantings which are adapted to various land conditions.
6. *The Bureau of Chemistry and Soils* conserves soil by offering new knowledge on methods of adapting crops to soils, and soils to crops.
7. *The Bureau of Plant Industry* offers new and established information on types and uses of plants for a great variety of environmental conditions.
8. *The Bureau of Agricultural Engineering* assumes responsibility for the machinery and techniques of erosion prevention and other services.
9. *The Farm Security Administration* through long time credit at low rates of interest, enables farmers to better regulate crop management, and individual programs of soil conservation.

SUMMARY OF THE ACTIVITIES OF SOME OF THE BETTER  
KNOWN CONSERVATION ORGANIZATIONS

*Prepared by ARTHUR O. BAKER, John Marshall  
High School, Cleveland, Ohio*

1. *Federal organizations*—See the preceding section of this report.
2. *The National Wildlife Federation*  
Washington, D.C.
  - a. *History of the Organization*  
This organization was proposed at the first North American Wildlife Conference held in Washington, D.C., 1936. The President of the United States, in his message to the first Wildlife Conference, summed up the needs for national organization in the following words:  
"My purpose is to bring together individuals, organizations and agencies interested in the restoration and conservation of wildlife resources. My hope is that through this conference new cooperation between Canada, Mexico, and this country will be developed; that from it will come constructive proposals for concrete action; that through these proposals existing State and Federal governmental agencies and conservation groups can work cooperatively for the common good."  
The organization was finally formed during the second North American Wildlife Conference which met in St. Louis in 1937.
  - b. *Purpose*  
To unite all conservation forces in support of legislation and policies beneficial to wildlife resources, and in opposition to those that are destructive. To promote public education in basic conservation principles.
  - c. *Activities*
    1. Projects providing for the restoration of wildlife are undertaken through the cooperation of the States and the United States Bureau of Biological Survey.
    2. Wildlife Week is promoted through the annual sale of wildlife

stamps. Profits are used in the promotion of conservation projects.

3. One of the primary objectives of the National Wildlife Federation is the development of an adequate program of education in wildlife conservation throughout the United States. To this end, the Federation is in active consultation with publishers, educational groups, scientific bodies, school and university executives, and the heads of youth organizations, working out various means of carrying the principles of scientific wildlife conservation and restoration to all future citizens.

*Summary of the Work of Some of the Better Known Organizations  
Affiliated with the National Wildlife Federation*

3. *Colorado State Conservation Council*

Denver, Colorado

Federation of many local organizations.

- a. Sponsors education in public schools.
- b. Drafts and works for passage of laws particularly to conserve wildlife.

4. *Connecticut Wildlife Federation*

17 Haynes St., Hartford, Connecticut

Coordinating Agency for conservation work in this State.

Composed of a number of state wide organizations.

*Aim:* To put conservation education into the school curriculum of Connecticut and to educate the public to the necessity for doing so.

5. *League of Kentucky Sportsmen*

Somerset, Kentucky

*Motto:* To educate the adult as well as the younger generation as to the value of our wildlife and natural resources.

- a. Designates third week in October as State Wildlife Week. Members go into all schools during this week on Conservation of Wildlife and natural resources.
- b. Distributes free material, magazines and charts on conservation.
- c. Publishes magazines and offers prizes in conservation story contests.

6. *Maryland Outdoor Life Federation*

29 S. Calvert St., Baltimore, Maryland

Federation of groups interested in Conservation and Outdoors. Sixty-six Member Organizations.

Introduced law to take conservation out of politics and to educate citizens as to value of conservation.

- a. Coordinates and stimulates the efforts of conservation, scientific, and outdoor organizations in making the most of outdoor life privileges and resources in the State of Maryland.
- b. Unifies the work of and serves as clearing house for all member organizations.
- c. Works for adoption of conservation teaching in all schools.
- d. Keeps legislation out of politics.
- e. Uses every means to increase organization membership by attempting to educate people.

7. *Mississippi Game and Fish Commission*

Jackson, Mississippi

- a. Sound conservation policies are being combined with naturally favorable conditions to further increase Mississippi's high standing in the affections of outdoor sportsmen.

- b. Woodlands and streams are being restocked.
  - c. Closed seasons, importation of new stock, and creation of protected havens have been the principal measures of the State Game and Fish Commission in the six years it has been engaging the problems of repopulation of State forests.
  - d. An educational program is sponsored. Posters are circulated. Lectures are given at schools and camps. A wildlife museum is maintained.
8. *Conservation Federation of Missouri*  
Springfield, Missouri  
Organization of County Chapters.
- a. Sets up wildlife refuges and fish rearing ponds, and creates a better understanding of principles of conservation and law enforcement on part of public.
  - b. Represents people before conservation commission.
  - c. Unifies conservation interests of the State and seeks beneficial legislation.
9. *Nebraska Wildlife Federation*  
220 Lefland Blvd., Omaha, Nebraska
- a. Finances restocking of pheasants.
  - b. Organizes 4H Clubs.
  - c. Distributes prizes to boys and girls who contribute most in conservation areas.
  - d. Remade recreational lake in State.
10. *New Mexico Game Protective Association*  
Deming, New Mexico  
*Program*
- a. To secure model game conservation laws.
  - b. To divorce the game department from political influence.
  - c. To promote an educational program.
11. *New York State Conservation Council*  
112 S. Hamilton St., Watertown, New York
- a. Prepares educational material for public schools.
  - b. Designs slogans for advertising material urging intelligent action by hunters.
  - c. Supplies speakers, arranges conferences and demonstrations to make people conservation minded.
  - d. Educational department plans certain courses to include conservation material especially biology courses.
12. *Cuyahoga County Conservation Council*  
2200 Prospect Avenue, Cleveland, Ohio
- a. Unifies the collective and individual efforts of conservation minded people of Northeastern Ohio.
  - b. Conducts surveys and research.
  - c. Cooperates with the Museum of Natural History and the Metropolitan Parks Board in conservation activities centering in the community, especially in and around the greater Cleveland Metropolitan Park System.
  - d. Plans programs of an educational nature for its individual and organization members.
  - e. Works through its membership for constructive conservation legislation.
13. *The League of Ohio Sportsmen*  
Southern Hotel, Columbus, Ohio
- a. The development of a definitely planned, long time conservation program for Ohio.

- b. The teaching of conservation in the schools.
  - c. The preservation of shorelines on streams and lakes for the use of the public, particularly with reference to new bodies of water.
  - d. State purchase of land along lakes and streams for conservation and recreation purposes.
  - e. The development of an adequate system of state parks, including parks on the shores of Lake Erie.
  - f. A continuous reforestation program, both on submarginal lands and along lakes and streams.
  - g. An adequate soil conservation program, with especial reference to agricultural lands.
  - h. An adequate water conservation program, including stream development, flood control, and the creation of artificial lakes and reservoirs.
  - i. An effectual program to solve the problem of stream pollution.
  - j. A program to bring about a wider appreciation of the kindred interests of farmers and sportsmen.
  - k. The encouragement of a program to cooperate with agriculture in the cultivation of game through the use of natural habitat.
  - l. Extension of the game management program to every county in the State, on a basis comparable to the county agricultural agent system.
  - m. The creation of National Parks in Ohio amounting to a minimum of a million acres.
  - n. Legislation or a constitutional amendment to take conservation out of politics.
  - o. The use of conservation funds for conservation purposes.
14. *Pennsylvania Federation of Sportsmen's Clubs*  
Wilkes-Barre, Pennsylvania
- a. The membership consists of 500,000 in 900 affiliated clubs.
  - b. Sponsored and helped pass a state anti-pollution bill.
  - c. Sponsoring a movement throughout the State to plant more trees and reforest barren areas.
  - d. Working with the Boy Scouts in winter feeding of game and birds.
  - e. Organized Junior Sportsmen's organizations.
15. *Rhode Island Wildlife Federation*  
Narragansett, Rhode Island  
Composed of delegates from almost every civic, youth, farm, sportsmen's, women's, and technical organization.
- a. Financially supports and aids a biological survey to determine suitability of the ponds and streams of Rhode Island as habitats for wildlife.
  - b. Creates a better understanding of needs of conservation among the general public.
  - c. Sponsors weekly radio conservation programs and distributes conservation displays.
  - d. Submits many successful legislation conservation measures.
16. *Texas Wildlife Federation*  
Galveston, Texas
- a. Has instituted a course in game management at Texas A and M College.
  - b. Has helped to secure the services of a wildlife specialist in the extension service.
  - c. State has been divided into 10 regions for research in conservation and wildlife restoration.

17. *Washington State Sportsmen's Council, Inc.*

Seattle, Washington

- a. Secured the passage of important legislation to conserve salmon of which there had been a 79% depletion in 20 years.
- b. Brought about a treaty with Canada to perpetuate salmon runs in international water.
- c. Succeeded in having overgrazing curtailed.
- d. Secured federal aid in propagation of salmon.
- e. Curbed water waste.

## SOME OF THE BETTER KNOWN CONSERVATION ORGANIZATIONS

1. U. S. Department of Agriculture
2. U. S. Department of the Interior
3. National Wildlife Federation  
Investment Building  
Washington, D. C.

*Organizations Affiliated with the  
National Wildlife Federation*

(in alphabetical order by States)

4. Alabama Wildlife Federation  
Thos. A. Ford—Sec. Treas.  
Box 1194  
Mobile, Alabama
5. Arizona Wildlife Federation  
W. H. Simms—Sec. Treas.  
79 Stone Ave.  
Tucson, Arizona
6. Arkansas Wildlife Federation  
Harold Wales—Sec. Treas.  
Mammoth Spring, Arkansas
7. Colorado State Conservation  
Council  
H. C. Kelly—Sec. Treas.  
1540 Sherman St.  
Denver, Colorado
8. Connecticut Wildlife Federa-  
tion  
Chas. B. H. Vaill—Sec.  
17 Haynes St.  
Hartford, Connecticut
9. Cuyahoga County Conserva-  
tion Council  
I. R. Watts—Sec.  
2200 Prospect Avenue  
Cleveland, Ohio
10. Delaware Game and Fish Pro-  
tective Association  
Florence M. Miles—Sec. Treas.  
Wilmington, Delaware
11. Florida State Fish and Game  
Association  
Merlin Mitchell—Exec. Sec.  
234 Mayer Arcade  
Orlando, Florida

12. Georgia Wildlife Federation  
Dr. Clabus Lloyd—Sec. Treas.  
Gainesville, Georgia
13. Idaho Wildlife Federation  
A. F. Riddle—Sec.  
Boise, Idaho
14. Illinois Federation of Sports-  
men's Clubs  
John J. Stolze—Sec.  
Granite City, Illinois
15. Indiana Wildlife Federation  
Cecil R. Swaim—Sec. Treas.  
519 Denny St.  
Indianapolis, Indiana
16. Iowa Wildlife Federation  
Fae Huttenlocher—Sec.  
Meredith Publishing Co.  
Des Moines, Iowa
17. Kansas Wildlife Federation  
Louise Dowling—Sec.  
Forestry, Fish, and Game  
Comm.  
Pratt, Kansas
18. League of Kentucky Sports-  
men  
Mrs. Dahlia Gooch—Sec.  
Somerset, Kentucky
19. Maryland Outdoor Life Feder-  
ation  
Granville C. Swope—Sec.  
29. S. Calvert St.  
Baltimore, Maryland
20. Massachusetts Conservation  
Council  
Carl H. Buchheister—Sec.  
Treas.  
66 Newbury St.  
Boston, Massachusetts
21. Michigan United Conservation  
Clubs  
Willis B. Perkins, Jr.—Sec.  
Grand Rapids, Michigan

22. Minnesota Wildlife Federation  
Kenneth W. Ingwalson—Sec.  
University Farm  
St. Paul, Minnesota
23. Mississippi Wildlife Federation  
Si Corley—Sec.  
Jackson, Mississippi
24. Conservation Federation of  
Missouri  
Lon S. Haymes—Sec. Treas.  
Springfield, Missouri
25. Montana Wildlife Federation  
M. T. Messelt—Sec.  
Great Falls, Montana
26. Nebraska Wildlife Federation  
Ernest Bibler—Sec.  
220 Leflang Blvd.  
Omaha, Nebraska
27. Protective Fish and Game  
Assn. of Nevada, Inc.  
Art Champagne—Sec.  
Reno, Nevada
28. Federated Sportsman's Clubs  
of New Hampshire, Inc.  
John F. Hill—Sec.  
36 Washington St.  
Exeter, New Hampshire
29. New Jersey State Federation of  
Sportsmen's Clubs  
George Scott—Sec.  
17 Lee Ave.  
Abasecon, New Jersey
30. New Mexico Game Protective  
Association  
Fred Sherman—Pres.  
Deming, New Mexico
31. New York State Conservation  
Council  
C. M. Dailey—Sec.  
112 S. Hamilton St.  
Watertown, New York
32. North Dakota Wildlife Asso-  
ciation  
J. G. Owens—Sec. Treas.  
Kindred, North Dakota
33. Ohio Natural Resources Council  
M. W. Tatlock—Sec. Treas.  
Dayton, Ohio
34. League of Ohio Sportsmen  
Southern Hotel  
Columbus, Ohio
35. Oklahoma Wildlife Conserva-  
tion Federation  
Luther Williams—Sec. Treas.  
Box 381  
Tulsa, Oklahoma
36. Oregon Wildlife Federation  
H. H. Stage—Sec. Treas.  
United States Court House  
Portland, Oregon
37. Pennsylvania Federation of  
Sportsmen's Clubs  
Dr. C. A. Mortimer—Sec.  
Treas.  
Wilkes Barre, Pennsylvania
38. Rhode Island Wildlife Federa-  
tion  
William H. Cotter, Jr.—Sec.  
Narragansett, Rhode Island
39. The South Carolina Game and  
Fish Association  
West Jacocks—Sec.  
Box 1405  
Columbia, South Carolina
40. The Garden Club of South Car-  
olina  
Mrs. Convers B. Woolsey—Sec.  
Treas.  
Aiken, South Carolina
41. Tennessee Wildlife Federation  
H. E. Baggenstoss—Pres.  
Noel Hotel  
Nashville, Tennessee
42. Texas Wildlife Federation  
Henry W. Flagg—Pres.  
Galveston, Texas
43. Utah Wildlife Federation  
C. E. Evans—Sec.  
Box 1122  
Salt Lake City, Utah
44. Vermont Wildlife Federation  
Prof. Lyman S. Rowell—Sec.  
Burlington, Vermont
45. Virginia Wildlife Federation  
Rosita E. Slusher—Sec.  
Blacksburg, Virginia
46. Washington State Sportsmen's  
Council  
Ken McLeod—Sec. Treas.  
Seattle, Washington
47. West Virginia Wildlife Federa-  
tion  
E. L. Lively—Sec.  
Fairmont, West Virginia
48. Wisconsin Wildlife Federation  
G. W. Colin—Sec.  
McFarland, Wisconsin
49. Wyoming Wildlife Federation  
Chiles P. Plummer—Sec. Treas.  
Cheyenne, Wyoming

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*Indianapolis, Indiana*

Additional suggestions by E. C. HOVEY, *John Marshall High School*  
*Cleveland, Ohio*

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### JUNIOR HIGH SCHOOL GROUP MEETING\* SATURDAY NOVEMBER 25, 1939

The Junior High School Group under the direction of F. R. Bemisderfer of Cleveland Ohio, had the opportunity of hearing three fine speeches.

Dr. Raleigh Schorling, Professor of Education, of the University of Michigan spoke on the Trends in Junior High School Mathematics.

Dr. Schorling showed graphically a specific class which revealed one of the common conditions with which most of the mathematics teachers have been confronted, that is, the problem of having one-half of a 7th grade class at a 5th grade performance level. Most teachers have turned to teaching of fundamentals by drill in order to remedy this situation, but it cannot be thus accomplished. It was shown that conditions of this sort can be remedied.

\* A report from the Annual Meeting of the Central Association of Science and Mathematics Teachers, Chicago, November 1939.

He pointed out that the trend in mathematics is toward general mathematics, but that this course has been stigmatized by teachers to whom symbolic work came easy. The second trend is toward greater uniformity of mathematical concepts taught in the 7th and 8th grade. The 9th grade still lacks uniformity of subject matter to be taught. There is a trend in the 9th grade to formulate in a general mathematics course, mathematical concepts which most students will need. Because present students feel the lack of adequate working knowledge of mathematics, Dr. Schorling predicts terrific pressure on fundamentals all through the senior high school will be the demand of these future citizens. He challenged us with the idea of a three level program in mathematics which will not be based on I.Q.'s and will not carry the stigmatism of present general mathematics. The levels suggested were: first, concepts for those who could quickly adopt symbolic thinking; second, concepts which would conform to the suggestions of the National Commission on Mathematics; third, for the group which found themselves behind in grade or the work too difficult to be given—not more drill as a remedy but—a program of activity. This activity program has experimentally shown improvement to groups of the type mentioned. They would do best and learn most from construction work with compass and protractor, graphic work of which examples are drawn from other subjects fields, statistics of a type not too difficult, scale drawing, percentage presented graphically (one phase of percentage having to be omitted because of difficulty in this method of presentation), and geometric construction. Another trend in mathematics leads us to the field of its social implications. Definite goals on the part of both the teachers and pupils will result in parents getting some idea of the work that the schools are trying to accomplish. There is still another tendency creeping upon us—that is toward broader concepts in which the pupil with the teacher will take part in the planning of the work needed by the pupils.

Dr. Frank Kirby of the Abbott Laboratories was out Catching Vitamins on Fish Hooks for us. In a very interesting and concise manner Dr. Kirby traced through the history of vitamins. The word first appearing in 1912: the substances being known only by their absence. It was a statement made by a chemist which led to an endless research program designed to disprove that chemist's assertion that halibut liver oil had fifty times more vitamins than cod liver oil. Dr. Kirby sketched briefly a picturesque true story of the halibut fishing industry. On the fish hooks were being caught vitamins A and D. He summarized the method of testing for the vitamin content. He brought out the idea that this testing is not the chemist's short method with the test tube but the long method which requires many weeks with the use of white rats. The testing for vitamin D is most difficult. The reason why humans suffer with decayed teeth and animals do not is because animals receive better food than man. In his choice of food man is catering to the eye and palate. Because soils become worn the mineral content of food lowers so tooth decay starts at an earlier age as shown by the English people. Another reason why we suffer with poor teeth is because we persist on using processing methods—refrigeration, canning, refining—on foods which we know result in a poorer food for man. He stated that the man eating angel food would soon be with the angels. There is a great waste of money in buying viosterol because people lack the knowledge that it is valueless without the D vitamin. He said that he was not advocating nudism but bringing attention to the fact that dry skin does not absorb the vitamins in the sun's energy. Because of the decrease in the radiant energy in this latitude foods such as eggs and milk have but very small vitamin content during the winter months. Each vitamin is associated with a definite tissue and unless we have had all, we could

not be healthy, happy human beings. We might suffer from loss of appetite, poor sleeping, nervousness and the like.

Sometimes it is interesting to take an inventory of one's own methods of teaching. In the clear presentation of Dr. George Skewes of the State Teacher College of Mayville, N.D. one was able to do just this. His subject on Spoiling the Scientific Attitude of Junior High School Students raised the question of whether the teachers were guilty of killing the young students' interest in science. Because teachers do not agree as to what is meant by scientific thinking and because we cannot measure our results we should not set up teaching the scientific attitude as a goal. In light of the fact that we are not able to justify our work as teachers by objectives, test-measured evidence, why do we want to develop scientific attitudes? It really isn't the mode in our world of today! We should not make him independent. We should not spoil the advertising field. We should not make it possible for him to oppose political bosses. We should prepare him for contented living in a dictatorship. It is an easier job of teaching to do just this. Supposing we wanted to do just this. We can kill interest in science by doing textbook teaching. Imagine, you have no apparatus to set up or put away or plan for. You would have no failures in demonstration. You could have the student memorize the book without understanding any of it. He could write tests in exact words of the book and thereby make easier correcting papers. Under such conditions the growing disciplinary problem will not be mentioned. Another sure way of killing interest is to have the text quoted as an authority. Have the student believe everything he reads. In your demonstrations tell him what is supposed to happen before you perform the experiment. Have long written reports with every one having the same form or do not require any kind of summary on demonstration shown. If you have problems set up as questions, be sure that they can all be answered with the simple word "yes." If a difficulty or question arises have the question settled democratically by a majority vote. If you do perform an experiment fake it so that you surely will get the desired results. In studying a problem be sure to obtain your generalization from but one case you have considered. You might use the unit plan that requires in the "overview" or "preview" an understanding not only of the problem but also its application to problems unknown to the child rather than have him get the understanding first and then see its application to problems or its relation to other things. You should give youth the idea that science has solved all problems and that there is nothing left for him to do, or give him the idea that machines or technology is responsible for the depression. If a child asks a question, tell him it is a very good question and that he look it up and report on it tomorrow or better still give the child the idea that you are a "know it all" teacher and give him the correct answer to all the questions. You should be a teacher who really has no interest in each child—leaving your school when the bell rings. Why not, if you are not, be a teacher who has "pets" so that you can have a social position of prestige in your community?

This all seems like a bad picture but the basic fault is the effect of trying to simplify the work so much that all thinking has been removed and along with it the interest is taken out.

Teachers in general do agree on many ideas that should be developed in giving or bringing out the scientific attitude. They believe that the cause and effect relationship should be developed and that few times will we have an effect from but a single cause. That there should be a clear differentiation in fact and theory. Theories should not be presented as facts. That pupils should base opinions on evidence and that a child should be willing to change opinion based upon new evidence. That progress in science still exists.

This was a challenge for all of us to prevent the killing of interest through any of the above "ruts" into which we may fall quite unconsciously.

Acting secretary  
PAULINE ROYT

## PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON

State Teachers College, Kirksville, Mo.

*This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.*

*All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution as on the following pages.*

*The Editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.*

## SOLUTIONS AND PROBLEMS

**NOTE.** Persons sending in solutions and submitting problems for solution should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solutions.
2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.
3. In general when several solutions are correct, the one submitted in the best form will be used.

## LATE SOLUTIONS

1622. John F. Wagner, Chicago.

1623. Leon Harter, Bowen, Ill.  
John F. Wagner, Chicago.

1624. Hugo Brandt, Chicago.  
Paul D. Thomas, Norman, Okla.  
John F. Wagner, Chicago.

1625. John F. Wagner, Chicago.  
Hugo Brandt, Chicago.

1626. Hugo Brandt, Chicago.

1627. Victor H. Pagnet, Poillard.

1628. Proposed by Cecil B. Read, University of Wichita, Wichita, Kansas.

Arrange the given numbers in such a manner that as  $n$  approaches infinity, the ratio of each number to the preceding also approaches infinity.

*Solution by M. Kirk, West Chester, Pa.*

The arrangement given below satisfies the requirements.  $(\log n)^2$ ,  $2^{\log n}$ ,  $n^2$ ,  $n^{\log n}$ ,  $2^n$ ,  $e^n$ ,  $n^n$ . The logarithmic base is  $e$ . The ratios may be

written as follows to show that they become infinite as  $n$  approaches infinity.

$$(1) \quad \frac{2 \log n}{(\log n)^2} = C \frac{2 \log n}{(\log n)^2} = C \frac{2^x}{x^2},$$

where  $x = \log n$ .

This ratio by use of Maclaurin Series is shown to approach infinity as  $n$  approaches infinity.

$$(2) \quad \frac{n^2}{2 \log n} = n \left( \frac{e}{2} \right)^{\log n}$$

$$(3) \quad \frac{n^{\log n}}{n^2} = (n)^{\log n - 2}$$

$$(4) \quad \frac{2^n}{n^{\log n}} = \frac{2^e}{e^{x^2}}$$

when  $x = \log n$  (use Maclaurin Series)

$$(5) \quad \frac{e^n}{2^n} = \left( \frac{e}{2} \right)^n$$

$$(6) \quad \frac{n^n}{e^n} = \left( \frac{n}{e} \right)^n$$

A solution was also offered by Leon Harter, Bowen, Ill.

1629. Proposed by John H. Meigham, Hillsdale, Michigan.

Prove that the equation

$$4n = -1 + \sqrt{1 + 2^{y+2}}$$

is satisfied by no pair of positive integers  $n$  and  $y$ .

*Solution by Leon Harter, Bowen, Illinois*

Transposing,  $4n + 1 = \sqrt{1 + 2^{y+2}}$ .

Squaring,  $16n^2 + 8n + 1 = 1 + 2^{y+2}$ .

Subtracting 1 from each side of the equation,

$$16n^2 + 8n = 2^{y+2}.$$

Factoring,  $8n(2n + 1) = 2^{y+2}$ .

But if  $n$  is a positive integer,  $(2n + 1)$  is odd, and if  $y$  is a positive integer,  $2^{y+2}$  is a positive integral power of 2 and cannot have an odd factor, all its prime factors being 2's. Therefore the given equation is satisfied by no pair of positive integers  $n$  and  $y$ .

Solutions were also offered by Edward C. Varnum, Clyde, Ohio, Harold Sogin, Chicago, Ill., Charles W. Trigg, Los Angeles, Aaron Buchman, Buffalo, N. Y., Alan Wayne, New York, N. Y., and also by the proposer.

1630. Proposed by George Redfield, East Varick, New York.

If  $x$ ,  $y$ , and  $z$  are real, prove that

$$\frac{x^2 + y^2 + z^2}{yz + zx + xy}$$

cannot have a value between 1 and  $-2$ .

*Solution by Edward C. Varnum, Clyde, Ohio*

Set the fraction equal to  $k$  and express as a quadratic in  $x$ :  $x^2 - k(y + z)x + (y^2 + z^2 - kyz) = 0$ .

The discriminant of this quadratic is  $k^2(y^2+2yz+z^2)-4(y^2+z^2-kyz)$ , which can be changed to  $(k^2-4)(y^2+z^2)+(2k^2+4k)yz$ , which factors into the form  $(k+2)[(k-2)(y^2+z^2)+2kyz]$ , or finally  $(k+2)[k(y+z)^2-2(y^2+z^2)]$ .

Now, if  $k > -2$ ,  $(k+2) > 0$ .

Also, if  $k < 1$ ,  $k(y+z)^2-2(y^2+z^2) < (y+z)^2-2(y^2+z^2) = -(y-z)^2 < 0$ .

Therefore, if both the above conditions on  $k$  hold at the same time, one of the factors of the discriminant is positive and the other factor is negative. However, a negative discriminant implies that  $x$  is not real, which contradicts our hypothesis and thus the given fraction cannot have a value between 1 and  $-2$ .

Solutions were also offered by Harold Sogin, Chicago, Ill., Aaron Buchman, Buffalo, N. Y., Hugo Brandt, Chicago, M. Kirk, West Chester, Pa.

**1631. Proposed by John Meyer, Lodi, New York.**

If the cubic derived from the equation

$$\frac{a}{x+a} + \frac{b}{x+b} = \frac{c}{x+c} + \frac{d}{x+d}$$

has a pair of equal roots then either one of the numbers  $a, b$ , is equal to one of the numbers  $c, d$ , or

$$\frac{1}{a} + \frac{1}{b} = \frac{1}{c} + \frac{1}{d}.$$

*Solution by Aaron Buchman, Buffalo, N. Y.*

$$\frac{a}{x+a} + \frac{b}{x+b} = \frac{c}{x+c} + \frac{d}{x+d}.$$

Clearing of fractions and simplifying

$$(a+b-c-d)x^3 + (2ab-2cd)x^2 + (abc+abd-acd-bcd)x = 0. \quad (1)$$

It is at once evident that one root of (1) is zero. If another root of (1) is to be zero, thus making two equal roots, then the coefficient of  $x$  must vanish, that is

$$abc+abd=acd+bcd.$$

Dividing by  $abcd$ , the condition becomes

$$\frac{1}{d} + \frac{1}{c} = \frac{1}{b} + \frac{1}{a}. \quad (2)$$

If instead, the two non-zero roots of (1) are to be equal, then by the theory of quadratic equations,

$$(2ab-2cd)^2-4(a+b-c-d)(abc+abd-acd-bcd)=0.$$

Multiplying out and factoring, the condition becomes

$$4(a-c)(a-d)(b-c)(b-d)=0.$$

That is, either

$$a=c \quad \text{or} \quad a=d \quad \text{or} \quad b=c \quad \text{or} \quad b=d. \quad (3)$$

Solutions were also offered by C. W. Trigg, Los Angeles, Will Spader, Hayts Corners, New York, Mrs. Walter Warne, Rochester, N. Y., Myron Rolison, Cayutaville, N. Y.

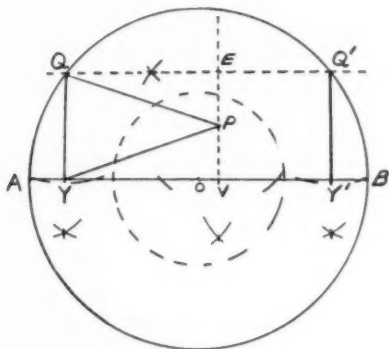
**1632. Proposed by Charles W. Trigg, Los Angeles City College.**

A given point  $P$  lies inside a circle of diameter  $AB$ . Find points  $Y$  on

the diameter such that  $PY = PQ$ , where  $QV$  is perpendicular to  $AB$  and  $Q$  is a point on the circle. If  $P$  is chosen at random what is the probability that a solution exists?

*Solution by Edward C. Varnum, Clyde, Ohio*

Construct  $PV$  perpendicular to  $AB$  meeting  $AB$  at  $V$ . Extend  $PV$  through  $P$  to point  $E$  such that  $PE = PV$ . At  $E$  construct a perpendicular to  $EV$  meeting the circle at  $Q$  and  $Q'$ . From  $Q$  and  $Q'$  construct perpendiculars to  $AB$  meeting  $AB$  at  $Y$  and  $Y'$  respectively.  $Y$  and  $Y'$  are the required points.



Because of the right angles at  $Y$ ,  $V$ , and  $E$ ,  $QEVY$  is a rectangle, making  $QE = YV$ . This with the equality of  $EP$  and  $PV$ , angles  $QEP$  and  $PVY$  proves the congruence of triangles  $QEP$  and  $PVY$  from which  $PV = PQ$ .

In order that this construction may give points  $Q$  and  $Q'$ ,  $P$  must lie within or upon two parallel lines each of whose distance from the diameter is  $\frac{1}{4}AB$ . The ratio of the area of this strip to the area of the entire circle is  $\frac{1}{2} + \sqrt{3}/2\pi$  or 0.609, which is the probability that a solution exists.

Solutions were also offered by Leon Harter, Bowen, Illinois, Hugo Brandt, Chicago, Aaron Buchman, Buffalo, N. Y., A. MacNeish, Chicago, W. R. Smith, and also by the proposer.

**1633.** *Proposed by Cecil B. Read, University of Wichita, Wichita, Kansas.*

Given that  $\tan \theta = \frac{1}{5}$ , prove that  $\theta$  is approximately  $\pi/16$ .

*First solution by the proposer*

Let  $x + iy = r(\cos \theta + i \sin \theta)$   
be applied where  $\tan \theta = \frac{1}{5}$ .

$$5 + i = 26(\cos \theta + i \sin \theta)$$

$$(5 + i)^4 = 676(\cos 4\theta + i \sin 4\theta)$$

$$476 + 480i = 676 \cos 4\theta + 676i \sin 4\theta.$$

Hence  $\cos 4\theta = 476/676$ ;  $\sin 4\theta = 480/676$ ; and  $\tan 4\theta = 480/476 = \text{unity}$ , approximately. Hence  $4\theta = \pi/4$  approximately, and  $\theta$  is approximately  $\pi/16$ .

*Second solution by Hugo Brandt, Chicago*

If  $\tan \theta = .2$ ,  $\tan 2\theta = 5/12$  and  
 $\tan 4\theta = 120/119 = 1$  approximately  $= \tan \pi/4$   
therefore  $4\theta = \pi/4$  approximately.

*Third Solution by Sidney V. Soanes, Toronto, Ontario*

$$\sin \theta < \theta < \tan \theta$$

$$1/\sqrt{26} < \theta < \frac{1}{3}$$

$$\pi/\sqrt{26\pi} < \theta < \pi/55$$

$$\pi/16.021 < \theta < \pi/15.710.$$

Therefore  $\theta = \pi/16$  approximately.

Solutions were also offered by W. R. Smith, Chicago, Edward C. Var-num, Clyde, Ohio, Leon Harter, Bowen, Ill., C. W. Trigg, M. Kirk, West Chester, Pa. Alan Wayne, New York, N. Y. and D. F. Wallace.

EDITOR'S NOTE: Dan T. Williams, Senior, State Teachers College, Platteville, Wis. offers a solution yielding a different one than the published solution of the December issue.

**1617.** *Proposed by I. N. Warner, Professor of Mathematics, State Teachers College, Platteville, Wisconsin.*

How many one-inch balls can be placed in a box measuring inside 5 inches by 10 inches?

*Solution by Dan T. Williams, Platteville, Wisconsin*

A. Turn the box so that a  $5'' \times 10''$  side is the base.

B. Place the first layer of balls in the box in the following way:

Place a row of balls across one end of the bottom. Since the box is  $5''$  wide, there will be 5 balls in this row. Place a second row of balls on the bottom next to the first row so that each ball in the second row will be tangent to two balls in the first row. Since there are 4 "spaces" between the 5 balls in the first row, there will be only 4 balls in the second row. Place a third row of balls on the bottom next to the second row. This third row will be similar to the first row, and likewise it will contain 5 balls. Continue placing the balls in the above manner. It will be noticed that this placing of the balls results in a hexagonal arrangement. The number of rows of balls can be determined as follows:

The distance from the line of centers of the first row of balls to the end of the box is a minimum of  $\frac{1}{2}''$ . Likewise  $\frac{1}{2}''$  is required between the lines of centers of the last row of balls and the end of the box. This leaves a maximum distance of  $9''$  between the lines of centers of the first and last rows. Now consider two balls in one row and a third tangent ball in an adjacent row. The lines connecting their centers form an equilateral triangle whose side is  $1''$ . The altitude of this triangle, which equals  $\frac{1}{2}$  of the square root of 3, or  $.866''$ , is the distance between the lines of centers of the two rows. In  $9''$  there will be room for 10.393 such distances. Actually this means that there will be 10 distances with .393 of a distance or  $.34''$  left over. We see now that there must be 11 rows of balls altogether, since there must be one more row than there are distances between rows. Of these 11 rows, 6 rows will contain 5 balls each, and 5 rows will contain 4 balls each. This makes a total of 50 balls in the first layer.

C. Place the second layer of balls in the following manner:

Place the first ball of row one, layer two so that it is tangent to balls one and two of row one, layer one and to ball one, row two, layer one. Continue a row of balls in this manner. This row will contain 4 balls, since there are four "spaces" or "pockets" into which they will fit. Row two of layer two is placed over the bottom layer as was row one of layer two. It is fitted next

to row one of layer two as was row three fitted to row two of layer one. The row will contain 5 balls, since there are "spaces" between the balls of layer one and the sides of the box. Succeeding rows are placed similarly in the second layer. The number of rows can be determined as follows:

There will be definitely room for 10 rows, since there are 11 rows in the first layer. Each row of layer two occupies a space in advance of the corresponding row in layer one by distance that is equal to  $\frac{1}{3}$  of the altitude of an equilateral triangle of side 1". This value is equal to  $\frac{1}{3}$  of  $\frac{1}{2}$  of the square root of 3 which equals .29". Since there was .34" between the last row and the end of the box in layer one, there will be room for a corresponding 11th row in layer two—this time with .05" to spare. There will thus be 11 rows of balls in the second layer, 6 of the rows will contain 4 balls each; 5 of the rows will contain 5 balls each. The total number of balls in the second layer will be 49.

D. The third layer of balls will be similar to the first layer; the fourth layer will be similar to the second, etc. The number of layers will now be determined:

The distance between the plane of centers of layer one and the bottom of the box is  $\frac{1}{3}$ ". Likewise the distance between the plane of centers of the last layer and the top of the box is a minimum of  $\frac{1}{3}$ ". This leaves 9" between the planes of centers of the bottom and top layers. If a pyramid of 4 balls be selected, the lines joining the centers of its balls will form a regular tetrahedron. The altitude of this tetrahedron, which is equal to .8165", is the distance between the planes of centers of two adjacent layers. In 9" there are 11.02 such distances. Actually this is 11 distances with something less than .02" to spare. Since there is one more layer than there are distances between layers, there will be a total of 12 layers in all. Of these layers 6 will contain 50 balls each, and 6 will contain 49 balls each. Adding there will be a total of 594 balls in the box.

### HIGH SCHOOL HONOR ROLL

The editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

For this issue the Honor Roll appears below:

1629. *Sidney V. Soanes, Toronto, Ontario, Canada.*

### PROBLEMS FOR SOLUTION

1646. *Proposed by Stephen Droemus, Willard, N. Y.*

If  $a, b, c$ , are real positive numbers, show that

$$\frac{1}{a} + \frac{1}{b} + \frac{1}{c} < \frac{a^8 + b^8 + c^8}{a^3 b^3 c^3}.$$

1647. *Proposed by a Reader.*

To draw a circle passing through points  $A$  and  $B$  of a given circle and cutting another given circle at opposite ends of a diameter.

1648. *Proposed by F. H. Wade, Chicago, Ill.*

Given the series

$$\sinh x = x + \frac{x^3}{3!} + \frac{x^5}{5!} + \dots$$

$$\cosh x = 1 + \frac{x}{2!} + \frac{x^3}{4!} + \dots$$

Find the series for

$$\frac{\sin^2 h x}{\cosh x - 1}$$

1649. *Proposed by Cecil B. Read, Wichita, Kansas.*

Solve the equations:

$$x + y + z = 6$$

$$xy + yz + xz = 11$$

$$xyz = 6.$$

1650. *Proposed by Roy Mac Kay, Portales, New Mexico.*

In the triangle  $ABC$ ,  $H$  is taken  $1/n^{\text{th}}$  of the way from  $B$  to  $C$ ;  $K$  is taken  $1/n^{\text{th}}$  of the way from  $C$  to  $A$ ;  $L$ ,  $1/n^{\text{th}}$  of the way from  $A$  to  $B$ . The lines  $AH$ ,  $BK$ ,  $CL$  form a triangle whose area is  $(n-2)^2/(n^2-n+1)$  times the area of the triangle  $ABC$ .

1651. *Proposed by John P. Hoyt, Cornwall, N. Y.*

If squares  $BDIC$  and  $ACKE$  are constructed on legs  $BC$  and  $AC$  respectively of right triangle  $ABC$ , the lines  $AD$  and  $BE$  are concurrent with the altitude to the hypotenuse.

## SCIENCE QUESTIONS

February, 1940

Conducted by Franklin T. Jones

*This department is a forum for discussing Tests, Experiments, Pedagogical Questions, Scientific Happenings, Practical Applications of Scientific Principles, Popular Beliefs and Misapprehensions concerning Scientific Matters, Newspaper Science, Think Problems (mostly scientific), Trick Questions, Borderline Science Questions involving Mathematical Treatment, College Entrance Examination Questions and Problems, any Problem or Question that will help teachers to make Science Teaching interesting.*

*The discussion usually takes the Question and Answer Form. Readers, whether teachers and students or outside school walls, are invited to propose Questions or Problems and to answer Problems and Questions proposed by others.*

*As a Mode of Recognizing contributors, the Guild of Question Raisers and Answerers (GQRA) has been formed and more than 325 contributors have already been admitted to Membership. Classes or individuals may become members by proposing a question or submitting an answer.*

(Send all communications to Franklin T. Jones, 10109 Wilbur Avenue, S. E. Cleveland, Ohio.)

### GQRA—NEW MEMBERS—February, 1940

326. Carrol C. Hall, Springfield, Ill., High School.

327. Lillian A. MacDonald, South Side H.S., Newark, N.J.

**PURE COPPER MAKES TROUBLE**

874. *Proposed by Carrol C. Hall (Elected to the GQRA, No. 326), Springfield, Ill. High School; Secretary, Chemistry Section, C.A.S. & M.T.*

In the Calumet & Hecla copper mine in the Lake Superior region, it has been found that some of the copper in the mine is *too pure*. In some cases this pure ore has occurred in such large quantities that when the miners came to it, they tunnelled around it instead of taking it out.

*Question:* What are the properties of copper that make this almost unbelievable situation true?

**SOLAR ECLIPSES OF 1940**

875. When and where will North America see its next solar eclipse? (*Answer for the March issue because the eclipse will occur early in April. Get your smoked or very dark colored glasses ready ahead of time.*)

**WHY USE CHAMOIS?**

876. *Proposed by Arthur L. Hill (GQRA, No. 115), Peru State Teachers College, Peru, Nebraska.*

What property of chamois skin not possessed by other materials makes it useful in wiping water off from polished surfaces without leaving streaks?

**LARGER AUTO TAGS MAKE EXTRA MILLION COST (?)**

877. Michigan auto tags for 1940 are larger than in 1939. (The change was made so that numbers would be more readable.)

A Michigan motorist claims that the extra wind resistance on new tags will "cost motorists an extra million dollars a year for fuel." What about it?

(Get out your aerodynamic handbooks and do some figuring.)

**WEIGH THE EVIDENCE**

878. *Proposed by Philip B. Sharpe (GQRA, No. 262), Greenwich, New York.*

A pupil collected the following data in regard to common blue writing ink:

1. It foams when chalk is added to it.
2. Tests show that the gas given off does not support combustion.
3. Carbon dioxide is commonly prepared by adding an acid to chalk, marble, or limestone.
4. It contains much water.
5. It turns litmus blue.
6. Acids turn litmus blue; bases turn litmus red.

In each of the blanks below, write the number of the corresponding statement above:

- \_\_\_\_\_ is false.
- \_\_\_\_\_ is irrelevant (of no value here).
- \_\_\_\_\_ represents the problem.
- \_\_\_\_\_ is true but misleading.
- \_\_\_\_\_ is a possible explanation.
- \_\_\_\_\_ is a valuable clue.

(Please try the above with your classes and submit results—Original papers desired. EDITOR.)

## NEON TUBE FLASHING CIRCUIT

879. *Proposed by Lillian A. MacDonald (Elected to the GQRA, No. 327), South Side H.S., Newark, N.J.*

"I have a small neon lamp purchased at a local radio store which is supposed to flash 120 times a second on a 115 volt 60 cycle line.

Is it possible, by using a radio tube and a variable condenser, to make the neon lamp flash much more slowly?

Can you tell me where to get a diagram of such a circuit, preferably simple enough for the average high school pupil to assemble?"

(Please send any library references.)

## DO YOU KNOW THE ANSWERS?

*You are invited to propose short questions, preferably with quick answers, for this section of SCIENCE QUESTIONS. Ask your class to supply a set or sets of individual questions. Credit will be given by membership in the GQRA.*

76. What is the shortest interval of time known?
77. What poisons are essential in your diet? (Science News Letter, March 4, 1939.)
78. What effect has chilling on cancer cells? (Science News Letter, May 13, 1939.)
79. Why do men grow old before their time? (Science News Letter, Feb. 18, 1939.)
80. What vitamin need increases with age? (Science News Letter, April 29, 1939.)

## ANSWERS to 66 to 70, December, 1939

66. *Fastest travel by human being*—Test Pilot Childs dove 575 m.p.h.
67. *Water off a duck's back*—A duck oils its feathers.
68. *Fastest running animal*—The cheetah.
69. *Chameleon changes color*—Emotional, light, temperature.
70. *Base of fine perfumes*—Ambergris.

## OTHER ANSWERS

869. *Proposed by Brother Felix John (GQRA, No. 17), Catholic High School, Pittsburgh, Pa.*

*Culled from the Advertisements—Answers by Brother Felix John*

1. Listerine Tooth Paste.

- (1) What is a detergent?

*Answer*—According to Webster's Unabridged Dictionary a detergent is: (1) a substance which cleanses the skin, as water or soap; (2) a medium to cleanse wounds, ulcers, etc.

- (2) What is the formula for "Luster Foam"?

*Answer*.— $C_{14}H_{27}O_5Na$ .

2. Böst Tooth Paste.

- (1) Explain the statement "Böst dissolves Coal Tars."

*Answer*.—Quoted from a letter to Brother F. John from a Vice-President of The Böst Tooth Paste Corp. "It is not coal tars but tobacco tars to which the Böst ad which you saw refers. Strictly speaking, it is possible that Böst does not actually dissolve the tar in the sense that benzine would for example. Rather does it wash the tar away as would a soap."

**871. Autumn Colors.**—Proposed by Alan Wayne (GQRA, No. 314), New York.

"Why do the leaves turn yellow, red and brown in the autumn?"

Answer by Alan Wayne

"Besides the familiar green catalyst, chlorophyl, leaves produce small amounts of zanthophyl, which is yellow, and erythrophyl, which is red, but these are masked by the preponderance of chlorophyl. As colder weather reduces the manufacture of chlorophyl, the red and yellow become apparent. Moreover, in trees like the maple and oak which have more sugars and tannic acid, the deep-lying erythrophyl is converted into bright red anthrocyanin. Dead leaves appear brown."

About lack of colors in 1939—

In line with the above explanation, the dry fall without frost let the leaves dry up without formation of anthrocyanin. Who knows the effect of a quick death of the living matter in the leaves by frost?

**873. Centrifugal Force.**—Definition on P. 347, *Amer. Phys. Teacher*, Oct., 1939.

"Centrifugal Force as the reaction of a body to an applied centripetal force is easily understood by the beginner if emphasis is placed on the fact that this reaction, since it is exerted by the given body rather than on it, does not affect the motion of the body."

### JOIN THE GQRA!

#### BOOKS AND PAMPHLETS RECEIVED

*A Text-Book of Heat*, by H. S. Allen, Professor of Natural Philosophy in the University of St. Andrews, and R. S. Maxwell. Part I. Cloth. Pages viii + 527 + xvi. 13.5 × 22 cm. 1939. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price \$3.25.

*Advanced Calculus*, by Ivan S. Sokolnikoff, Associate Professor of Mathematics, University of Wisconsin. Cloth. Pages x + 466. 15 × 23 cm. 1939. McGraw-Hill Book Company, Inc., 330 W. 42nd Street, New York, N. Y. Price \$4.00.

*Principles of Unit Construction*, by Arthur J. Jones, Professor of Secondary Education, University of Pennsylvania; E. D. Grizzell, Professor of Secondary Education, University of Pennsylvania; and Wren Jones Grinstead, Director, School of Demonstration and School of Business, Rider College. Cloth. Pages x + 232. 14.5 × 23 cm. 1939. McGraw-Hill Book Company, Inc., 330 W. 42nd Street, New York, N. Y. Price \$2.00.

*Physical Meteorology*, by John G. Albright, Assistant Professor of Physics, Case School of Applied Science. Cloth. Pages xxvii + 392. 15 × 23 cm. 1939. Prentice-Hall, Inc., 70 Fifth Avenue, New York, N. Y. Price Trade \$5.35, School \$4.00.

*Elementary Theory of Equations*, by William Vernon Lovitt, Professor of Mathematics, Colorado College. Cloth. Pages xi + 237. 15 × 23 cm. 1939. Prentice-Hall, Inc., 70 Fifth Avenue, New York, N. Y. Price \$2.50.

*A Short History of Science*, by W. T. Sedgwick and H. W. Tyler. Revised by H. W. Tyler and R. P. Bigelow. Cloth. Pages xxi + 512. 13.5 × 21.5 cm.

1939. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price \$3.75.

*Learning Activities in Elementary Algebra*, by Earl J. Burnett, Head of Department of Mathematics, Monroe High School, Rochester, N. Y., and Regina Grosswege, Department of Mathematics, Elwood High School, Elwood, Indiana. Paper. Pages iv+228. 20×26.5 cm. 1939. College Entrance Book Company, Inc., 104 Fifth Avenue, New York, N. Y. Price 66 cents.

*Mastery Tests to Accompany Elementary Algebra*. Paper. 20 pages. 20×26.5 cm. 1939. College Entrance Book Company, Inc., 104 Fifth Avenue, New York, N. Y.

*Learning Activities in Plane Geometry*, by Earl J. Burnett, Head of Department of Mathematics, Monroe High School, Rochester, N. Y., and William E. Batzler, Department of Mathematics, Battle Creek High School, Battle Creek, Michigan. Paper. Pages viii+248. 20×26.5 cm. 1939. College Entrance Book Company, Inc., 104 Fifth Avenue, New York, N. Y. Price 68 cents.

*Mastery Tests to Accompany Learning Activities in Plane Geometry*. Paper. 30 pages. 1939. College Entrance Book Company, Inc., 104 Fifth Avenue, New York, N. Y.

*A Workbook and Laboratory Manual in Earth Science*, by Donald B. Stone, Teacher of Earth Science, Mont Pleasant High School, Schenectady, New York. Paper. Pages vii+278. 20×26.5 cm. 1939. College Entrance Book Company, Inc., 104 Fifth Avenue, New York, N. Y. Price 72 cents.

*Unit Tests in Earth Science to Accompany A Workbook and Laboratory Manual in Earth Science*, by Donald B. Stone. Paper. 30 pages. 20×26.5 cm. 1939. College Entrance Book Company, Inc., 104 Fifth Avenue, New York, N. Y.

*Growing Plants in Nutrient Solutions*, by Wayne I. Turner, and Victor M. Henry. Cloth. Pages xiii+154. 15×23 cm. 1939. John Wiley and Sons, Inc., 440 Fourth Avenue, New York, N. Y. Price \$3.00.

*Lecture Demonstrations in General Chemistry*, by Paul Arthur, Assistant Professor of General and Analytical Chemistry, Oklahoma Agricultural and Mechanical College. Cloth. Pages xvi+455. 14×20.5 cm. 1939. McGraw-Hill Book Company, Inc., 330 W. 42nd Street, New York, N. Y. Price \$4.00.

*American Mammals, Their Lives, Habits, and Economic Relations*, by W. J. Hamilton, Jr., Cornell University. Cloth. Pages xii+434. 1939. McGraw-Hill Book Company, Inc., 330 W. 42nd Street, New York, N. Y. Price \$3.75.

*Elementary Mathematics from an Advanced Standpoint. Geometry*, by Felix Klein. Translated from the Third German Edition by E. R. Hedrick, Vice President and Provost, The University of California, and C. A. Noble, Professor of Mathematics, Emeritus, The University of California. Cloth. Pages ix+214. 153×23.5 cm. 1939. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price \$3.50.

*Teacher's Manual to Accompany Consumer Science*, by Alfred H. Hausrath, Jr., Director of Student Teaching, Iowa State College, Ames, Iowa, formerly Supervisor of Student Teaching, Ames High School; and John H. Harms, Head of the Science Department, Ames (Iowa) High School and Supervisor of Student Teaching in Science, Iowa State College. Paper. 125 pages. 13.5 × 20.5 cm. 1939. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price 60 cents.

*Elementary Calculus*, by G. W. Caunt, Late Reader in Mathematics at King's College, Newcastle-upon-Tyne. Cloth. 388 pages. 12 × 18 cm. 1939. Oxford University Press, 114 Fifth Avenue, New York, N. Y. Price \$2.75.

*Physics Workbook*, by Mahlon H. Buell, Department of Physics, Senior High School, Ann Arbor, Michigan, and Frederick W. Schuler, Department of Physics, West High School, Madison, Wisconsin. Paper. Pages vi + 378. 19 × 26 cm. 1939. Price \$1.00. A Teachers' Answer Key and Separate Unit Tests are furnished free to all Teachers who order Physics Workbook for classroom use. J. B. Lippincott Company, 220 No. Michigan Avenue, Chicago, Ill.

*The School Auditorium as a Theater*, by Alice Barrows, Senior Specialist in School Building Problems, Office of Education, and Lee Simonson, Scenic Designer and Theater Consultant, New York City. Bulletin 1939, No. 4. Pages v + 51. 15 × 23 cm. For sale by the Superintendent of Documents, Washington, D. C. Price 10 cents.

*Public High Schools having Counselors and Guidance Officers*, by Walter J. Greenleaf and Royce E. Brewster, Specialists, Occupational Information and Guidance Service. Paper. 39 pages. 13 × 20 cm. Federal Security Agency, U. S. Office of Education, Washington, D. C.

*State Personnel Administration with Special Reference to Departments of Education*, by Katherine A. Frederic with an Introduction by Walter D. Cocking. Staff Study Number 3. Prepared for The Advisory Committee on Education. Paper. Pages xiv + 271. 14.5 × 23.5 cm. 1939. For sale by the Superintendent of Documents, Washington, D. C. Price 35 cents.

*Natural History of Santa Catalina Island*, by T. D. A. Cockerell, Professor Emeritus of Zoology, University of Colorado. Reprinted from *The Scientific Monthly*, April, 1939, Vol. xlviii. 11 pages. 17.5 × 25 cm.

*College General Mathematics for Prospective Secondary School Teachers*, by Lee Emerson Boyer, Instructor of Mathematics, State Teacher College, Millersville, Pennsylvania. Paper. 106 pages. 14.5 × 23 cm. 1939. School of Education, The Pennsylvania State College, State College, Pa.

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## BOOK REVIEWS

*Consumer Science*, by Alfred H. Hausrath Jr. Director of Student Teaching, Iowa State College, Ames, Iowa and John H. Harms, Head of the Science Department, Ames (Iowa) High School. Cloth. Pages xii + 692. 16.5 × 24 cm. 1939. The Macmillan Co., New York, N. Y. Price \$2.40.

As the title implies, Consumer Science deals with the application of scientific principles to life in such a way as to develop intelligent consump-

tion of everyday commodities. There is a complete departure from the stereotyped physical science sequence without too much sacrifice of continuity. Mathematical problems have been reduced to a minimum and the activities suggested while interesting and instructive do not require extensive mathematical ability. Some of the problems suggested while having a definitely practical slant, nevertheless are sufficiently searching in character as to require a mastery of the principles involved before a solution can be obtained. The book consists of 37 chapters grouped under the following six unit headings:

- I. Understanding Science
- II. Living With Machines
- III. Everyday Electricity
- IV. Applied Chemistry
- V. Applying Consumer Science
- VI. Science and the Welfare of Man

The typography is excellent and the book is written in such a style as to be very easily read. The illustrations are clear and easily understood, this is especially true of the many diagrams of devices in common use.

The chapters on Safety are also noteworthy as they give extensive treatment to this most pressing of current problems.

Teachers and pupils alike will enjoy reading this book.

WILLIAM A. PORTER

*The Photographic Process*, by Julian Ellis Mack, Assistant Professor of Physics, University of Wisconsin, and Miles J. Martin, Professor of Physics, Milwaukee Extension Center University of Wisconsin. Cloth. Pages xvii + 586. 17.5 × 24 cm. 1939. McGraw-Hill Book Company, 330 W. 42nd Street, New York, N. Y. Price \$5.00.

This book is designed for use as a textbook in photography at the college level. Courses in general chemistry and physics are not prerequisite but will be helpful. After a brief historical introduction the authors devote over a hundred pages to geometrical and physical optics and a very thorough discussion of lenses. A chapter on cameras of all types and their accessories follows. A comprehensive treatment of the photographic emulsion, its structure, properties and response to light, the exposure and development of the negative, and numerous auxiliary processes such as reduction, intensification, retouching, and reversal are presented both in theory and in their practical aspects. The discussion of the processes involved in making positive prints includes a critical study of print papers, transparencies, lantern slides, and enlarging. The fundamental ideas of the physics of color and its applications in color sensitive emulsions and filters, and the various methods of natural-color photography are briefly discussed. The chapters on scientific and technological photography, photo-mechanical reproduction, and photography as a means of artistic expression contribute much to the cultural value of a course in photography as well as to its practical significance. The fundamental science content and the method of presentation give the book high scientific value, while the practical hints throughout, the valuable appendixes, and the 45-page manual of experiments supply the practical material for a technical course. This book will be very useful to both the professional and the amateur photographer. Its foundation of basic science, interesting approach, and artistic appearance make it a desirable addition to the home library.

G. W. W.

*A Workbook and Laboratory Manual in Earth Science (Physiography)*, by Donald B. Stone, Teacher of Earth Science, Mont Pleasant High School, Schenectady, New York. Paper. Pages vii + 278, Maps, Tables, 43 Fig. 20.75 × 26.25 cm. 1939. College Entrance Book Co., Inc., 104 Fifth Avenue, New York City.

In schools where Physiography is taught as a year course this Workbook and Manual will be of value. The material is organized in Four Units. Each Unit is divided into Topics. Each Topic has a list of references, an exercise based upon the references, review questions and advanced work, a scientific vocabulary, suggested activities, exercises and review test.

The book directs the attention of the student to definite things in a reading assignment. It provides the teacher a quick and effective means of checking. It deals with facts and provides opportunity for these facts to be recorded and reviewed. It would keep a class well occupied along very definite lines.

VILLA B. SMITH

*Unit Tests in Earth Science*, by Donald B. Stone, Teacher of Earth Science, Mont Pleasant High School, Schenectady, N. Y. Paper. Pages 30 perforated. 20 × 26.25 cm. 1939. College Entrance Book Co., Inc., 104 Fifth Avenue, New York City.

These tests accompany the *Workbook and Laboratory Manual in Earth Science (Physiography)* by Donald B. Stone. The organization of the course is such that Two Units are covered each half year. The tests are based on divisions of each Unit. Term Examinations cover the work of each half year. A Final Examination covers the work of the entire year. The tests provide exercises in matching and in completing; opportunity to supply factual information and to state reasons why; opportunity to make diagrams and to label diagrams provided. These tests together with those provided in the Workbook hold the student to very definite information. They may so dominate the learning situation that facts become ends in themselves.

VILLA B. SMITH

*Deserts*, by Gayle Pickwell, Ph.D. Cloth. Pages xiv + 174, 64 illus., 23 × 28.5 cm. 1939. Whittlesey House, McGraw-Hill Book Company, Inc., New York.

The 64 full page illustrations, 63 of which are photographs, are the core about which the printed pages deal. Each photograph is explained and described in a fascinating manner. The text puts meaning into the pictures; the pictures put meaning into the text. This close relationship makes desert landscapes, desert plants and desert animals abound with interest. This close relationship makes the pictures function and makes the desert world one of reality.

The rain shadow deserts; the deserts of winter's cold; the deserts of summer's dry; the deserts of lakes' and oceans' dunes; the deserts of salt; the deserts of wet are discussed and illustrated. Explanations are forceful and vivid. Many excellent geographic relationships are a part of the presentation.

The Chapter, "How to Know the Deserts and Desert Problems," presents an outline which can serve in many ways. It would be of service to both geography and biology teachers. Its reference to illustrations again shows how vital pictorial material can be. The Bibliography is likewise organized to serve teachers and students interested in deserts and desert problems.

VILLA B. SMITH

*Plane Trigonometry, With Tables*, by W. T. Stratton, Professor of Mathematics, Kansas State College; R. D. Daugherty, Assistant Professor of Mathematics, Kansas State College. Cloth. Pages vii+88+118. 16×23.5 cm. 1939. Prentice-Hall, Inc., 70 Fifth Avenue, New York, N. Y. Price \$2.25.

The authors have written a short simple text covering the easier portions of the material usually presented in modern texts on trigonometry. The approach is via the plane right triangle. The definitions for the general angle follow. The emphasis is on applied problems—many good problems are given. There are few difficult identities. Some teachers will find it necessary to treat by lecture many of the more technical portions of the subject. The text is well suited for a high school course or a brief college course in trigonometry.

J. J. CORLISS, *DePaul University*

*Modern-School Solid Geometry*, by Rolland R. Smith, Specialist in Mathematics, Public Schools, Springfield, Massachusetts and John R. Clark, The Lincoln School of Teachers College, Columbia University. Cloth, viii+248 pages. Illustrated. Price \$1.28. World Book Company, Yonkers-on-Hudson, New York. 1939.

This book is another contribution in the "Schorling-Clark-Smith, Modern School Mathematics Series."

In the preface the authors set forth, "the primary purposes to be achieved through the study of solid Geometry as:

1. The discovery of Geometrical truths of three-dimensional space and their establishment by logical methods.
2. The development of computational skill . . . in the mensuration of common geometrical solids.
3. The practice of perceptual analysis. . . .
4. An extension of understanding in the nature of logic."

In keeping with the above purposes the authors by the modernization of their teaching methods have produced a book unusual in its clearness and teachability. It contains good introductory material and suggestions to the student, which should lead him past the many obstacles that beset him at the beginning of the course. An abundance of exercises, carefully graded, and involving both arithmetical and algebraic computations, the use of indirect proofs, will help to develop ability on the part of the student in reasoning, analysis, and appreciation of spatial relationships.

The book contains nine (9) chapters with headings as follows:

1. Introductory.
2. Perpendicular lines and planes.
3. Parallel lines and planes.
4. Dihedral and polyhedral angles.
5. Locus and projections.
6. Polyhedrons.
7. Cylinders and Cones.
8. Spheres.
9. Spherical polygons-spherical volumes.

In the appendices are listed, symbols, axioms and definitions, a syllabus of propositions in Plane Geometry, and an index.

The book is attractively bound, each page is clear and well organized, and the illustrations are well drawn. The book should be welcomed by both students and teachers of mathematics.

HYMEN D. SILVERMAN, *Foreman High School, Chicago, Illinois*

*First Course in Theory of Numbers*, by Harry N. Wright, Associate Professor of Mathematics, The City College, New York. Cloth. Pages vii + 108.  $14 \times 21.5$  cm. 1939. John Wiley and Sons, Inc., New York, N. Y. Price \$2.00.

While this text seems obviously written for an undergraduate one semester course, at the same time it could profitably be read by anyone who wishes to get an introduction to the topic. The explanation is usually clear and illustrative examples are rather frequent. The material covered is somewhat traditional, as is indicated by the chapter headings: divisibility, simple continued fractions, congruences, quadratic residues, Diophantine equations. The author points out that there might be disagreement with the emphasis placed upon certain topics. The text contains over 250 exercises for the student, in most places they seem sufficient in number but at a few points a somewhat larger selection might have been advisable. The typography is excellent.

CECIL B. READ, *University of Wichita*

*Development of the Minkowski Geometry of Numbers*, by Harris Hancock, University Station, Charlottesville, Virginia. Cloth. Pages xxiv + 839.  $13.5 \times 21.5$  cm. 1939. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price \$12.00.

The statement of the author that in his belief this work covers all that was published by Minkowski on the Geometry of Numbers makes it obvious that this is by no means an elementary text book. No doubt it will be a valuable addition to the library of reference works in any university. If this work is considered as a sequel to Dr. Hancock's *Foundations of the Theory of Algebraic Numbers* one has in the two treatises an idea of the close connection between algebraic numbers and the geometry of numbers.

It is of course obviously impossible in a brief review to cover the content of the book. Some vague idea may be presented by stating that an arithmetic significance is given to geometrical studies based primarily upon a three dimensional lattice although there is application to manifolds of arbitrary order. The convex body is used to a great extent, the definition being in terms of a set of points. The concepts of the usual Euclidean geometry are greatly generalized.

Historical material is found at several points of the book, in fact one might even question whether several of these historical interludes might not have made an excellent introduction to the subject. The introduction contains an obvious misprint of Sanford for Stanford on page xiii. In two or three cases the reviewer found that an attempt to again locate passages that had appealed to him on first reading revealed the fact that the index is not absolutely complete.

CECIL B. READ, *University of Wichita*

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